Ansys ModelCenter MBSE

Supporting Digital Mission Engineering through Integrated Modeling and Simulation

INCOSE Huntsville

July 21, 2022

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Demonstration of ModelCenter MBSE

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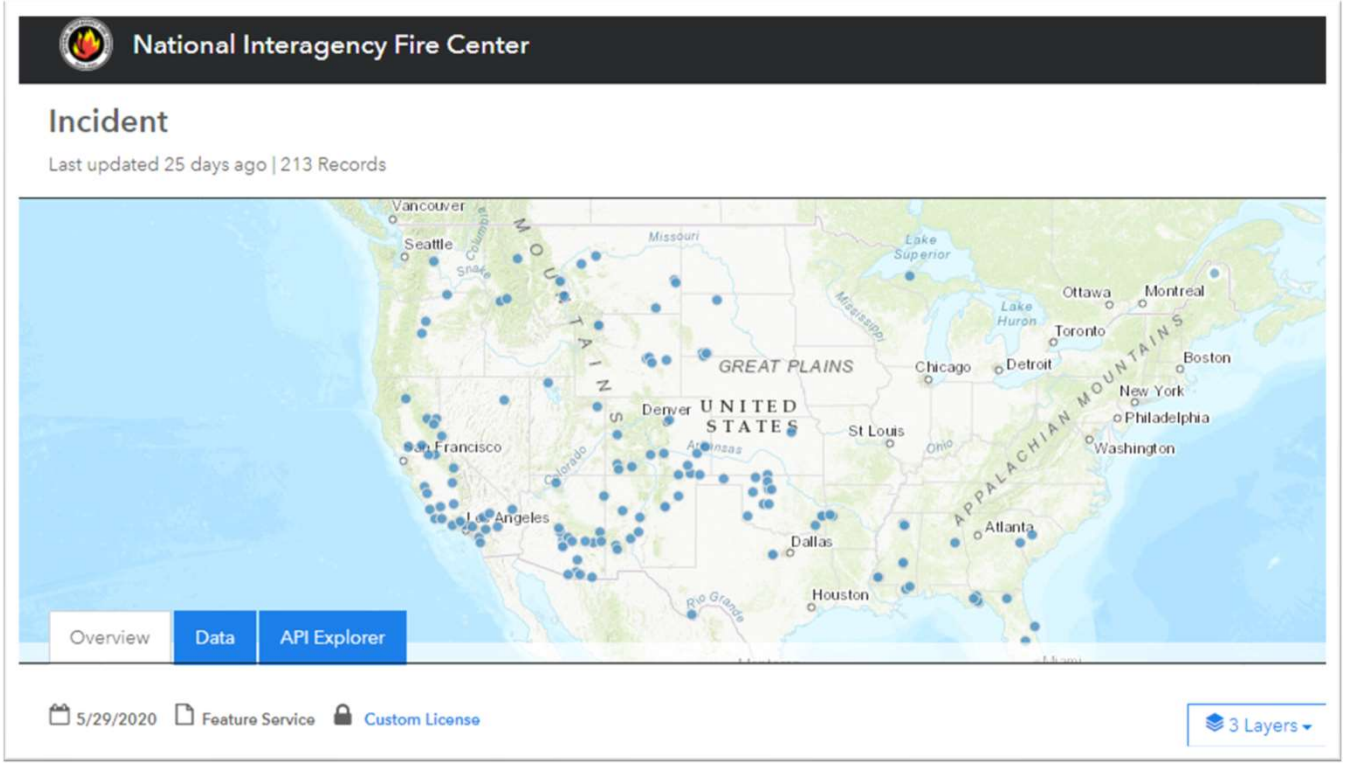
Demo Objective

Define a system of systems that detects and communicates the existence of wildfires in "real time"



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Demo Agenda

1. **DME Models** - Review the STK, ANSYS, Excel, and Cameo models
2. **Integrate DME Models** - Integrate DME models into ModelCenter workflow
3. **Integrate MBSE Model** - Connect ModelCenter workflow to Cameo SysML model
4. **Increase Model Fidelity** - Increase the fidelity of the antenna pattern for STK
5. **Requirement Changes** - Handle requirement changes to the SysML model

Review the STK, ANSYS, Excel, and Cameo models

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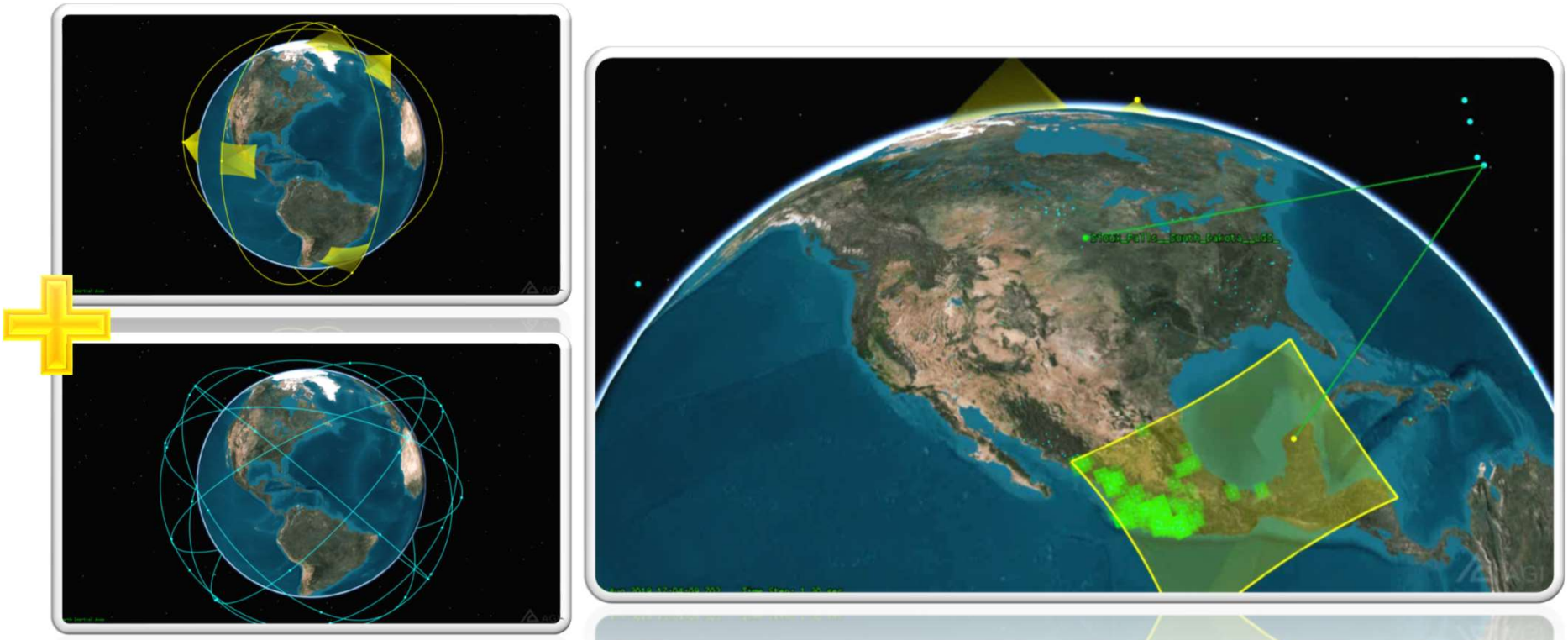
The Mission

- Detect and Communicate Wildfires



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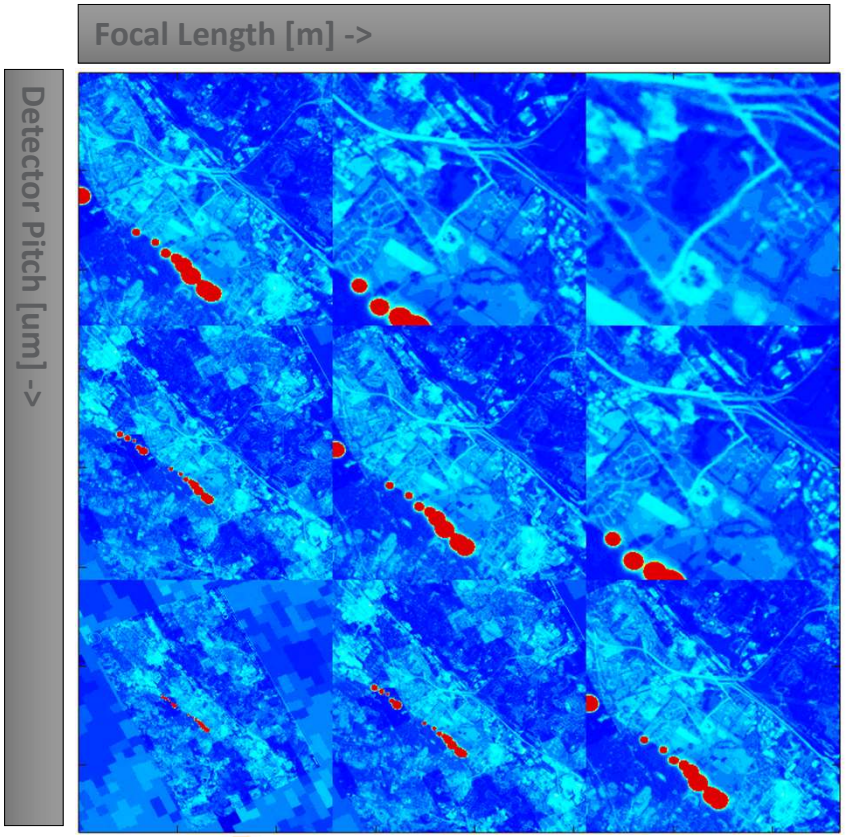
Detecting Wildfires

- Sensing Constellation



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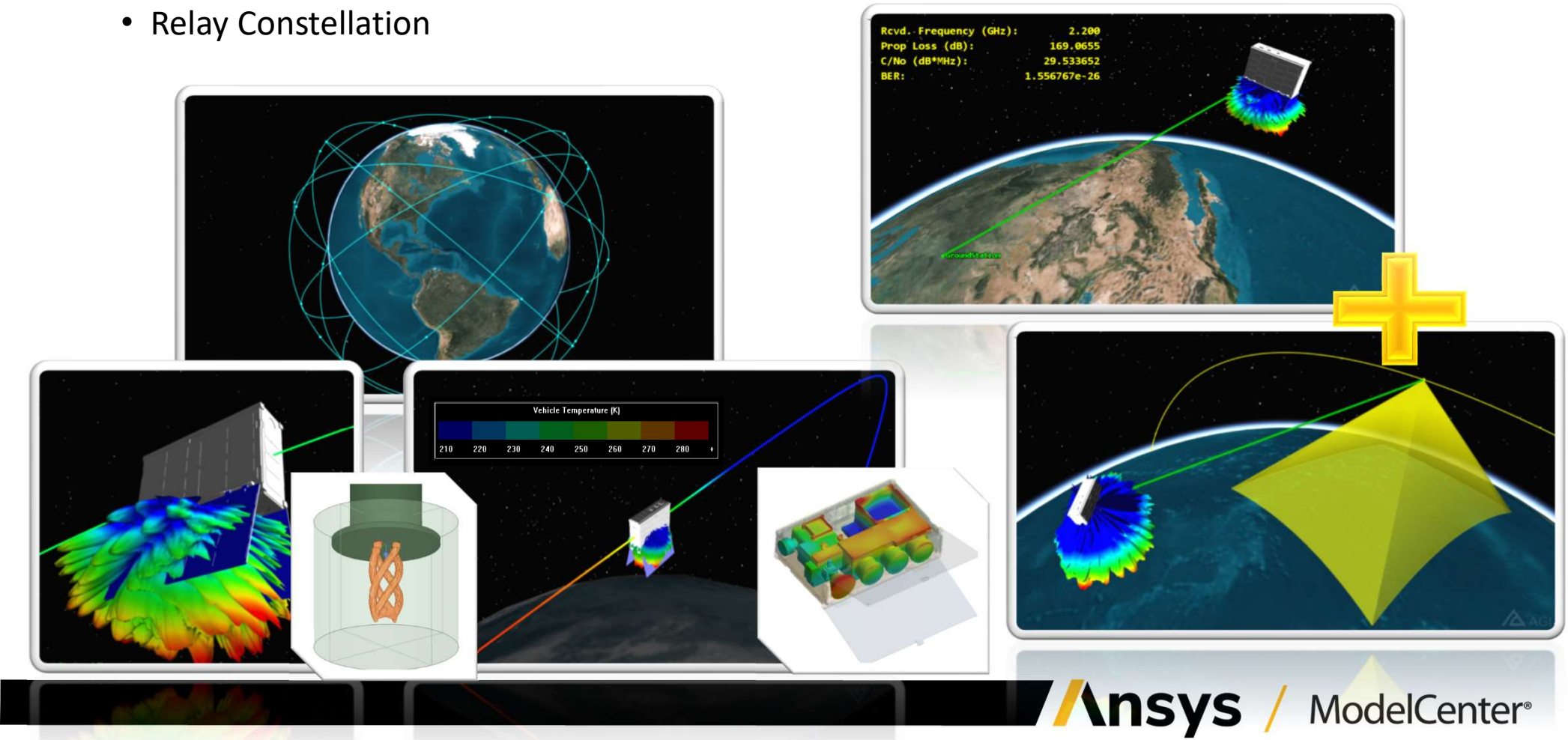
Communications

- Relay Constellation



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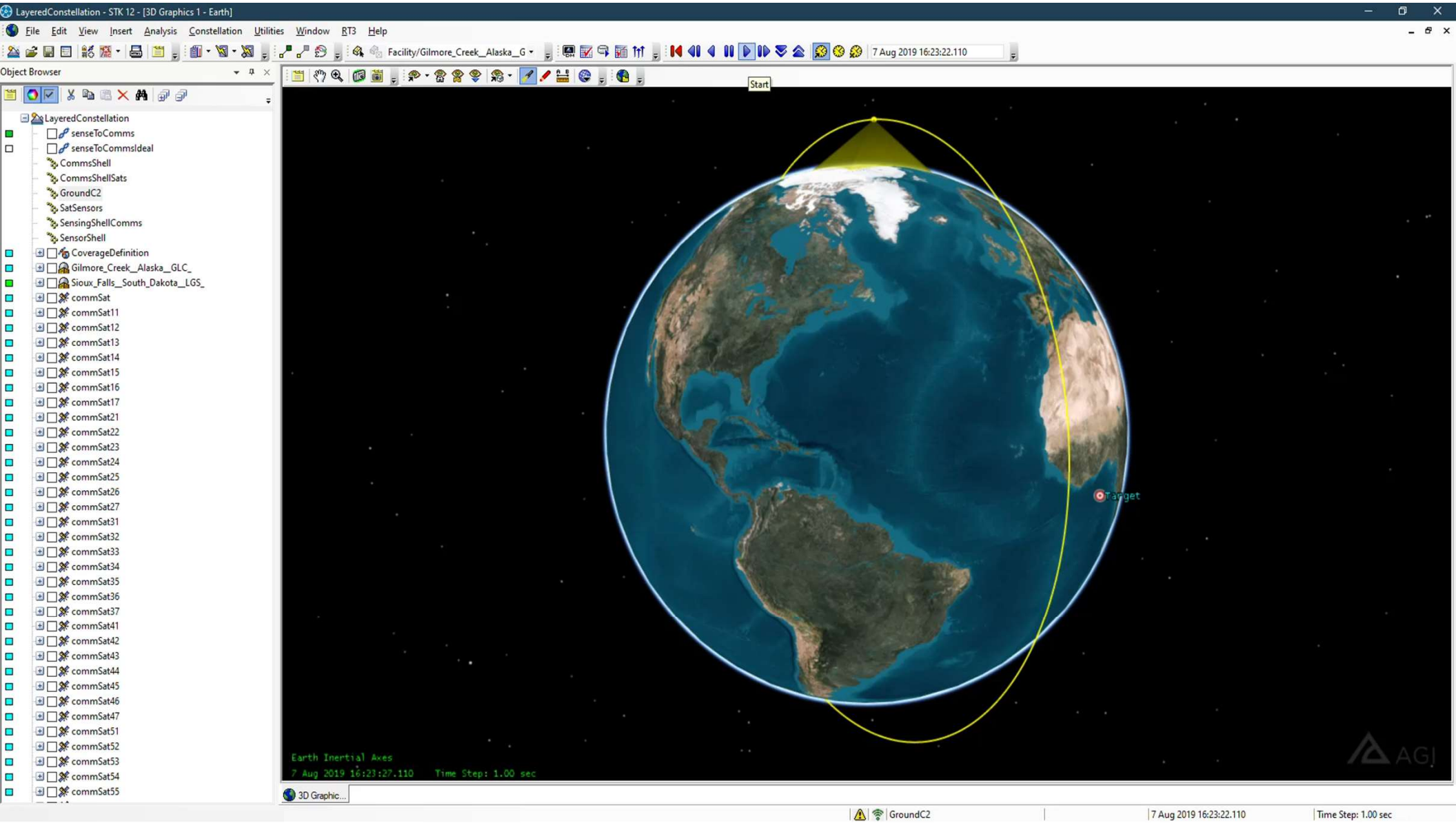
Mission Requirements

1. The sensing system shall collect imagery with a **ground sample distance** less than **10 meters** in order to detect any wildfire in North America greater than 2 acres
2. The communications system shall provide link availability with less than **7.5% outage** which corresponds roughly to one orbital period per day
3. Overall system **revisit time** shall be less than **4 hours** to support an adequate response time
4. **Total cost** shall be less than **$130 million**


LayeredConstellation - STK 12 - [3D Graphics 1 - Earth]
File Edit View Insert Analysis Constellation Utilities Window RT3 Help
Facility/Gilmore_Creek__Alaska__G
7 Aug 2019 16:23:22.110
Object Browser
LayeredConstellation
senseToComms
senseToCommsIdeal
CommsShell
CommsShellSats
GroundC2
SatSensors
SensingShellComms
SensorShell
CoverageDefinition
Gilmore_Creek__Alaska__GLC_
Sioux_Falls__South_Dakota__LGS_
commSat
commSat11
commSat12
commSat13
commSat14
commSat15
commSat16
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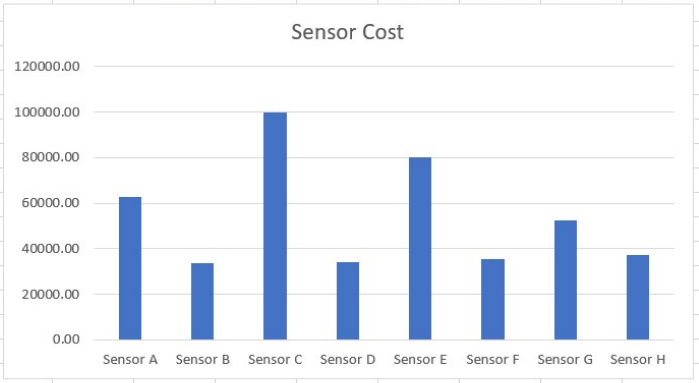
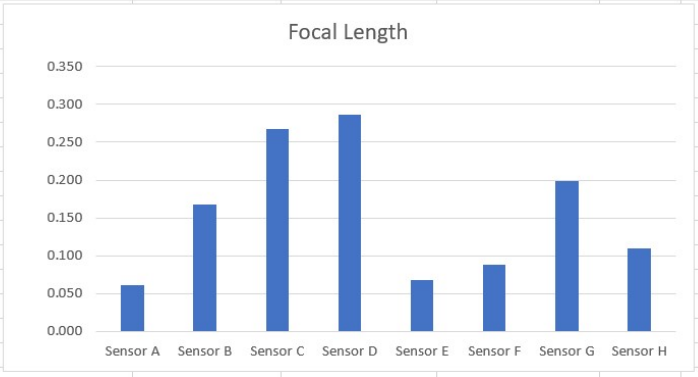
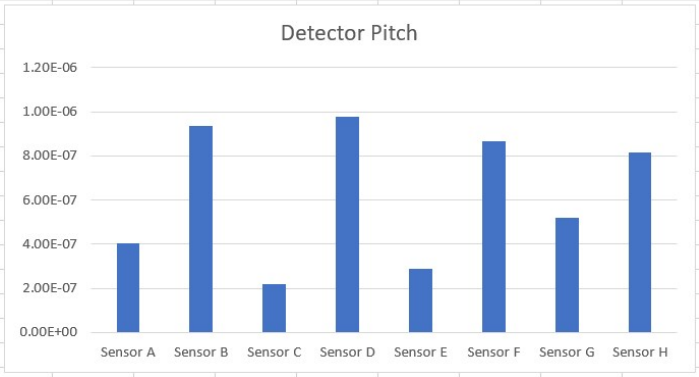
commSat41
commSat42
commSat43
commSat44
commSat45
commSat46
commSat47
commSat51
commSat52
commSat53
commSat54
commSat55
Start
Target
Earth Inertial Axes
7 Aug 2019 16:23:27.110 Time Step: 1.00 sec
AGI
3D Graphic...
GroundC2
7 Aug 2019 16:23:22.110
Time Step: 1.00 sec

Sensor Catalog Spreadsheet

	A	B	C	D
1	**Sensor Option**	Sensor B		
2	**Detector Pitch**	9.35E-07	m	
3	**Focal Length**	0.17	m	
4	**Sensor Cost**	33837.04	$	
5				
6	**SENSOR CATALOG**			
7	**Sensor Option**	**Focal Length (m)**	**Detector Pitch (m)**	**Cost ($)**
8	Sensor A	0.061	4.03E-07	62565.71
9	Sensor B	0.168	9.35E-07	33837.04
10	Sensor C	0.267	2.21E-07	99728.81
11	Sensor D	0.286	9.79E-07	34021.74
12	Sensor E	0.068	2.89E-07	80302.79
13	Sensor F	0.088	8.68E-07	35298.34
14	Sensor G	0.199	5.19E-07	52552.36
15	Sensor H	0.110	8.17E-07	37019.14







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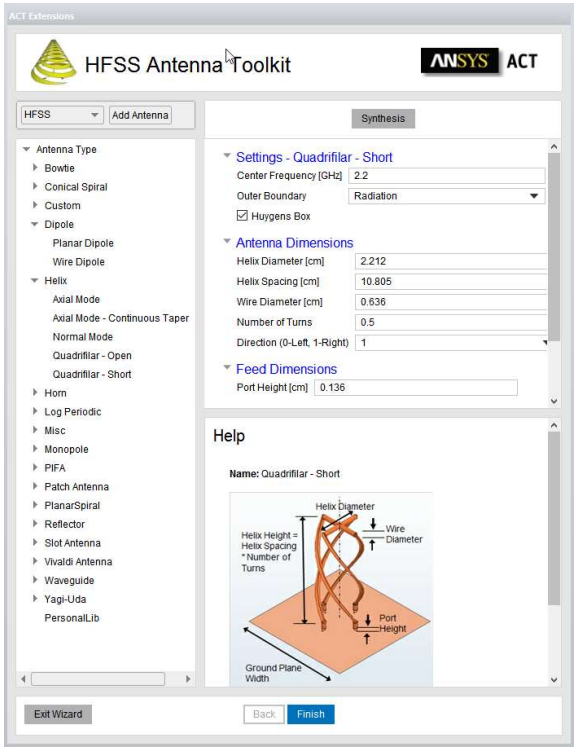
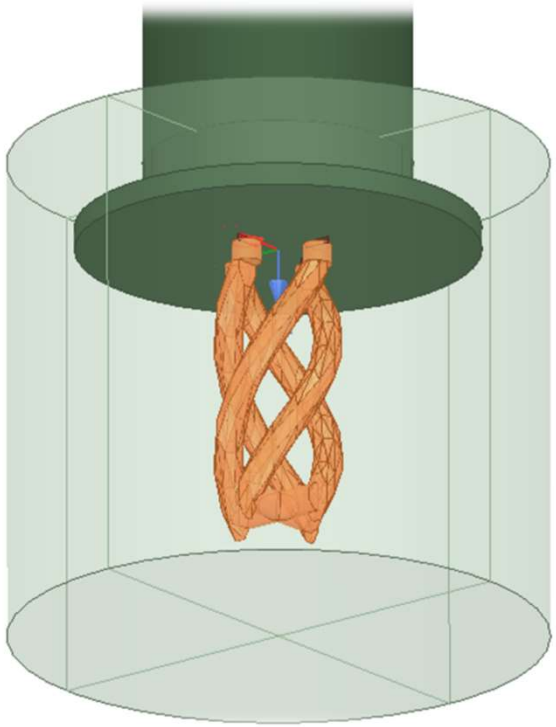
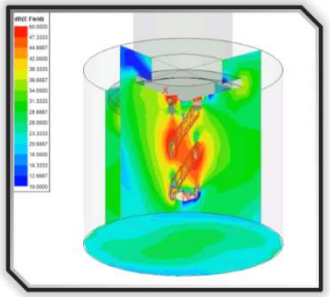
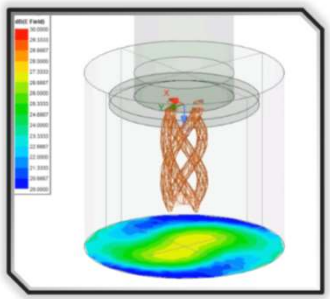
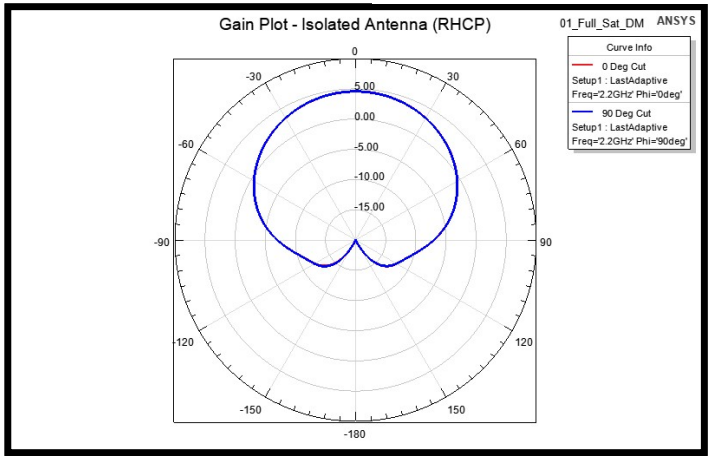
Modeling the Antenna











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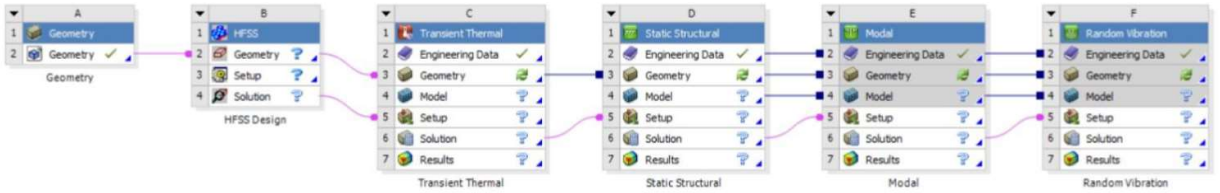
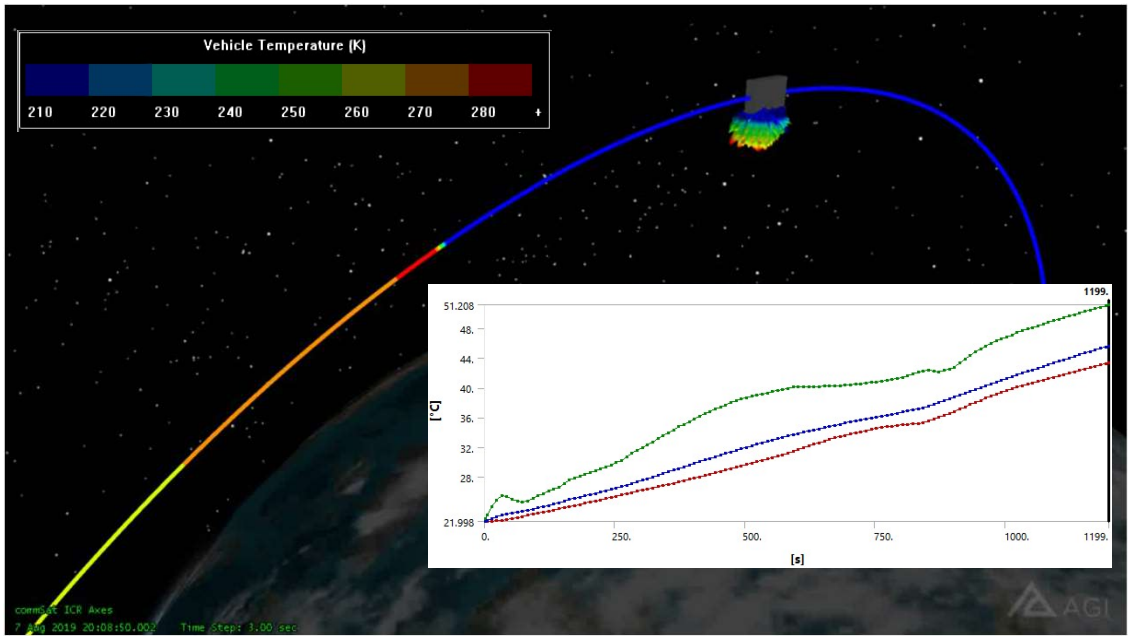
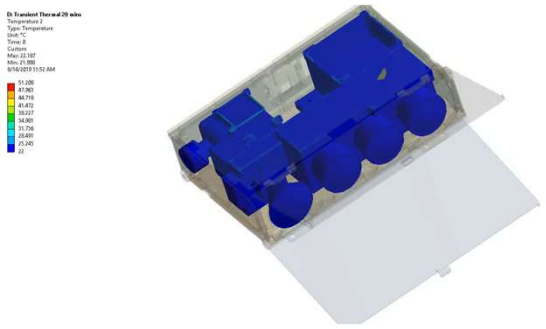
Transient Thermal Analysis of Satellite

Transient Thermal Analysis







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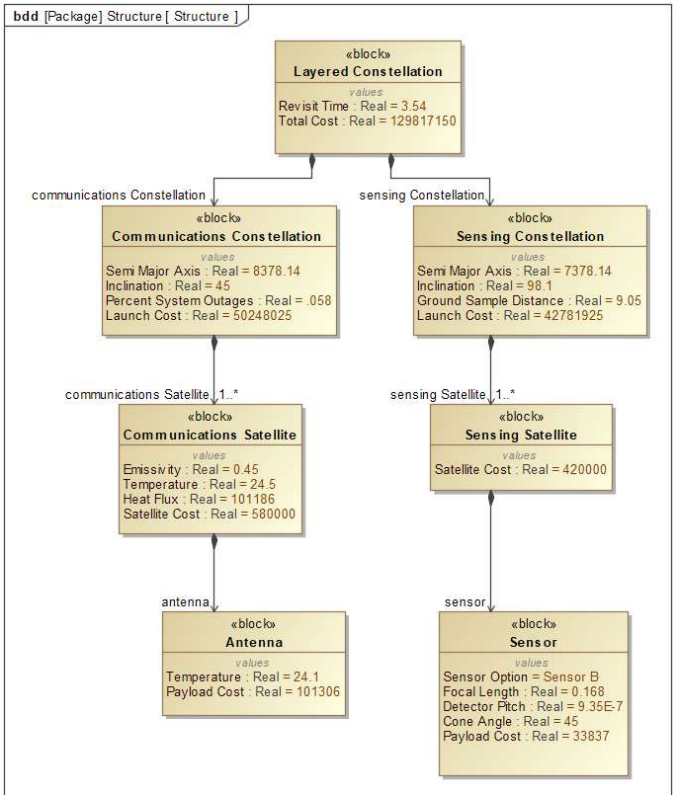
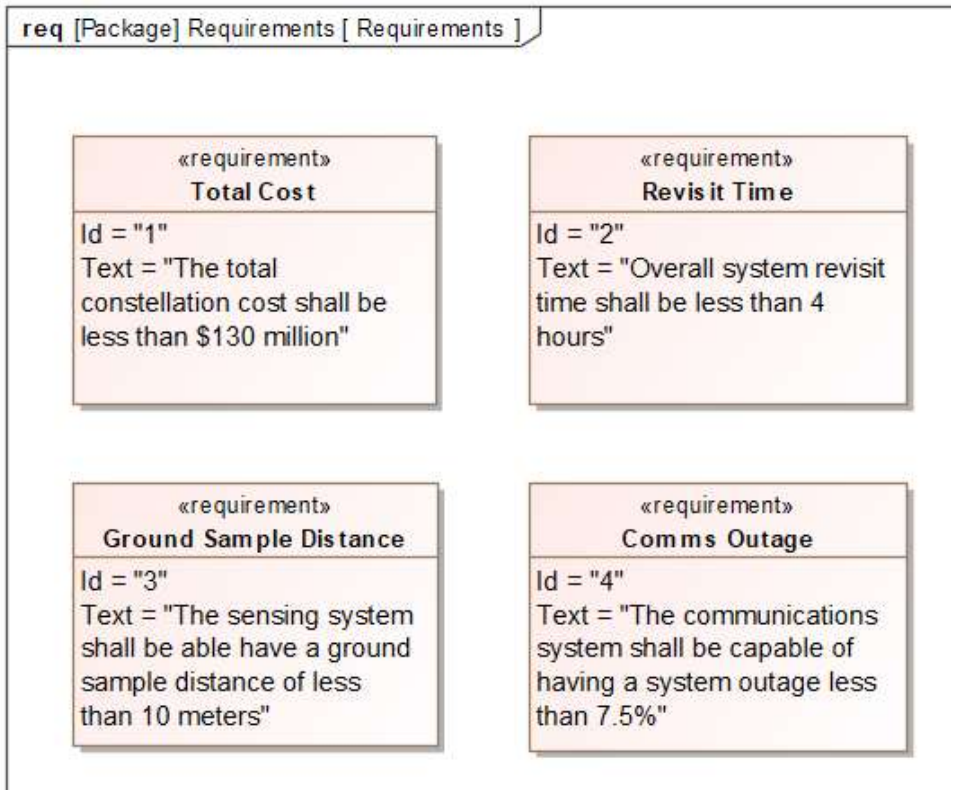
Layered Constellation Cost Spreadsheet

	A	B	C	D	E	F	G
1							
2	**Satellite Cost Analysis**						
3		**Comms**	**Sensing**				
4	Cost per Satellite:	$580,000	$420,000				
5	Launch Cost:	$50,248,025	$42,781,925				
6	Payload Cost:	$101,306	$33,837				
7	Number of Sats:	48	9				
8		**TOTAL COST:**	**$129,817,150**				
9							
10	**Comms Launch Cost**				**Sensing Launch Cost**		
11							
12	Semi Major Axis (km) :	8378.14	$22,000,140		Semi Major Axis (km) :	7378.14	$16,400,140
13	Inclination (deg):	45	$1,650,000		Inclination (deg):	98.1	$5,359,200
14	Overhead:		$20,000,000		Overhead:		$15,400,000
15	Maneuver Cost:		$6,597,885.00		Maneuver Cost:		$5,622,585.00
16		**LAUNCH COST:**	**$50,248,025**			**LAUNCH COST:**	**$42,781,925**
17							
18	**Comms Payload Cost Estimate**				**Sensing Payload Cost Estimate**		
19						**PAYLOAD COST:**	**$33,837**
20	Beamwidth(deg)	55	$16,806				
21	Power (W):	3	$67,500				
22	Overhead:		$17,000				
23							
24		**PAYLOAD COST:**	**$101,306**				

Cameo SysML Model





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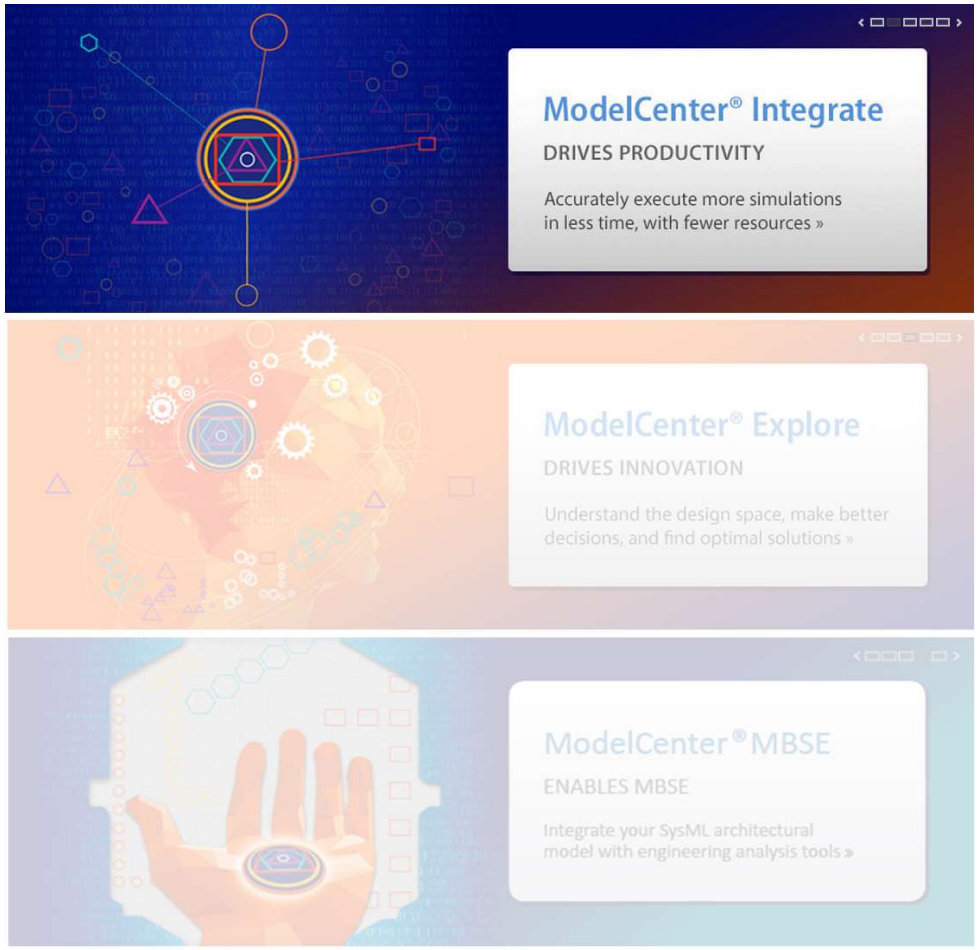
Integrate DME models into ModelCenter

Ansys



- ModelCenter Integrate
  - **Automate**
  - **Integrate**
  - To Create a Workflow

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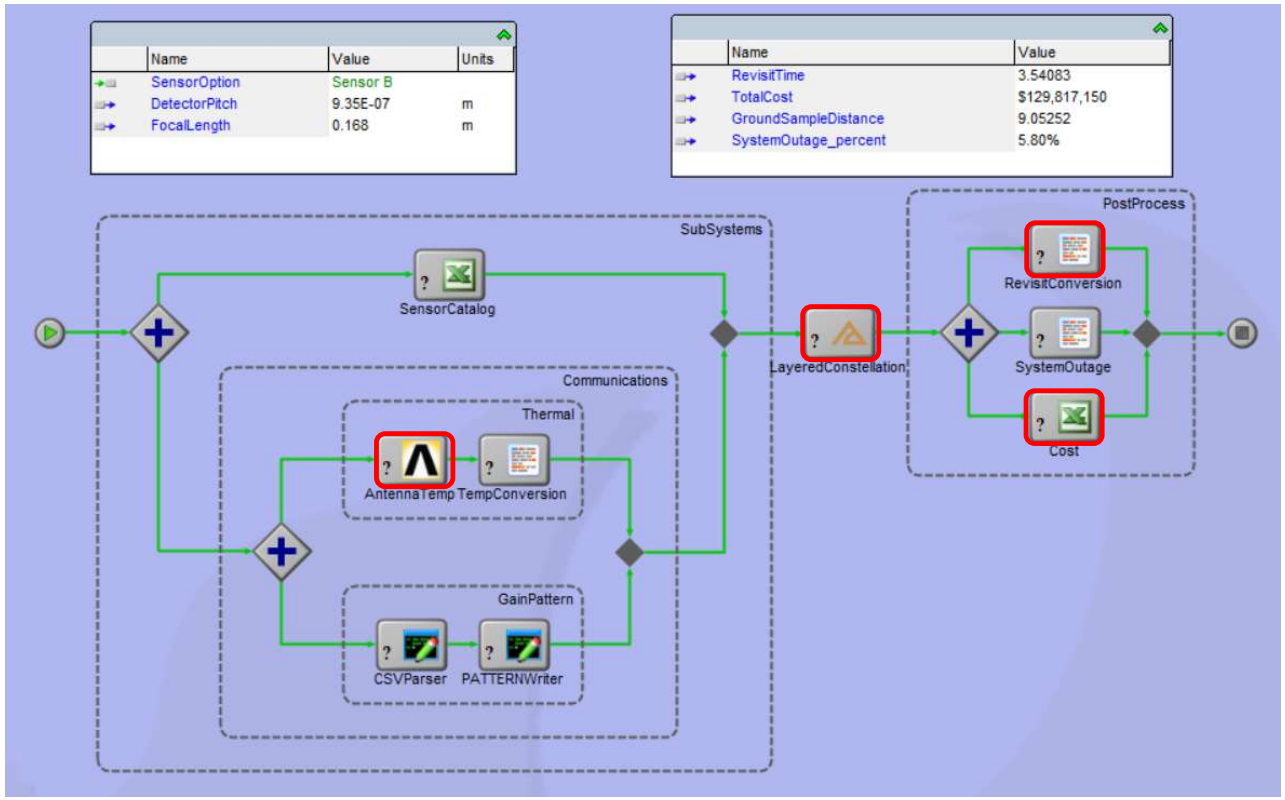
ModelCenter Wildfire Workflow



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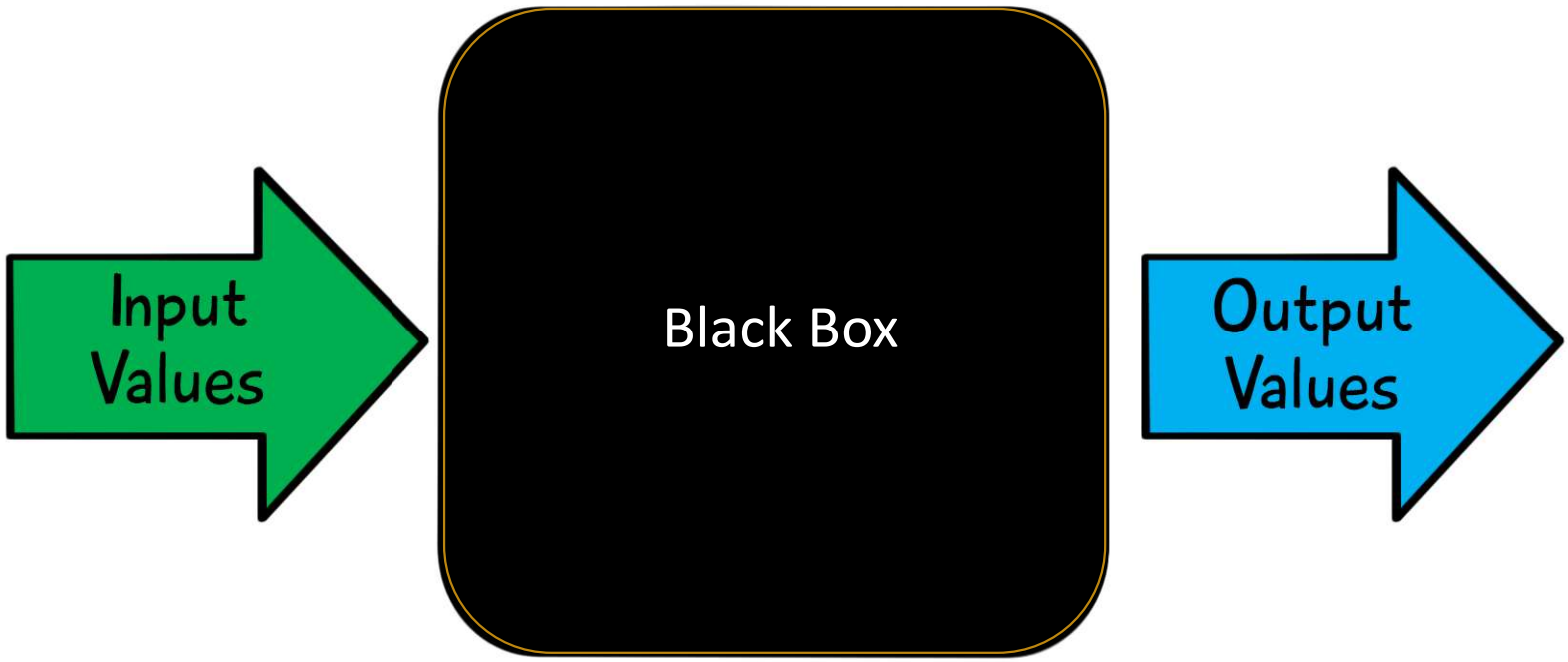
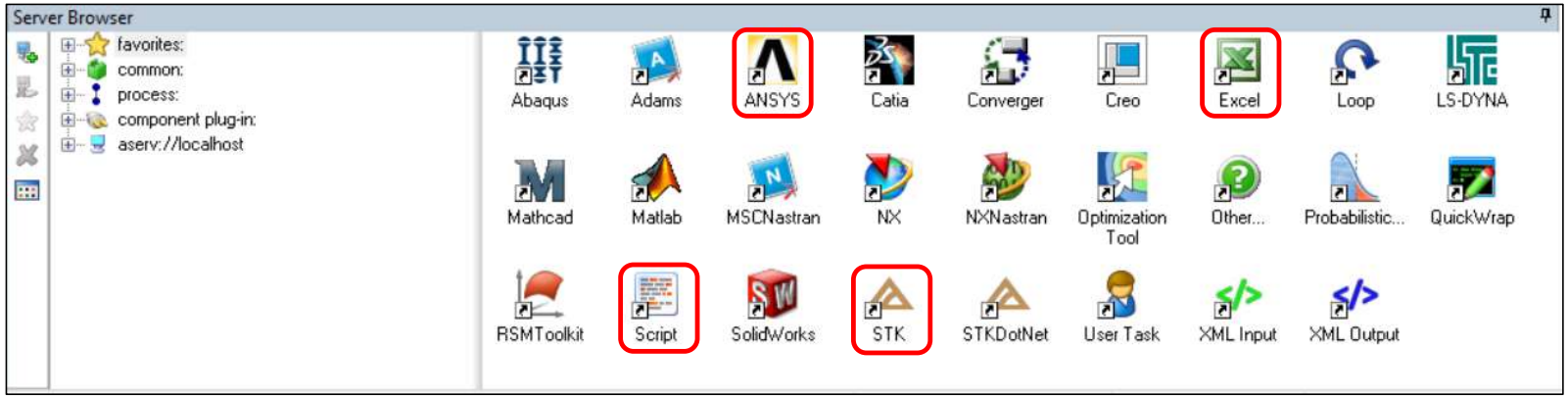
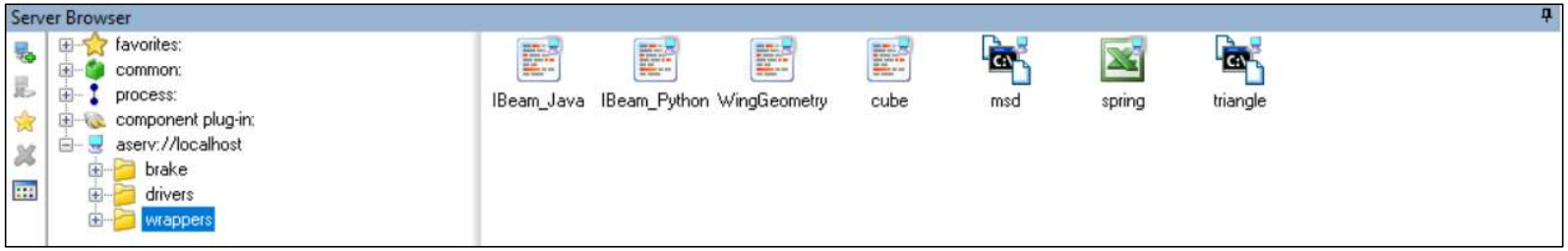
Automating with ModelCenter



Automating with ModelCenter





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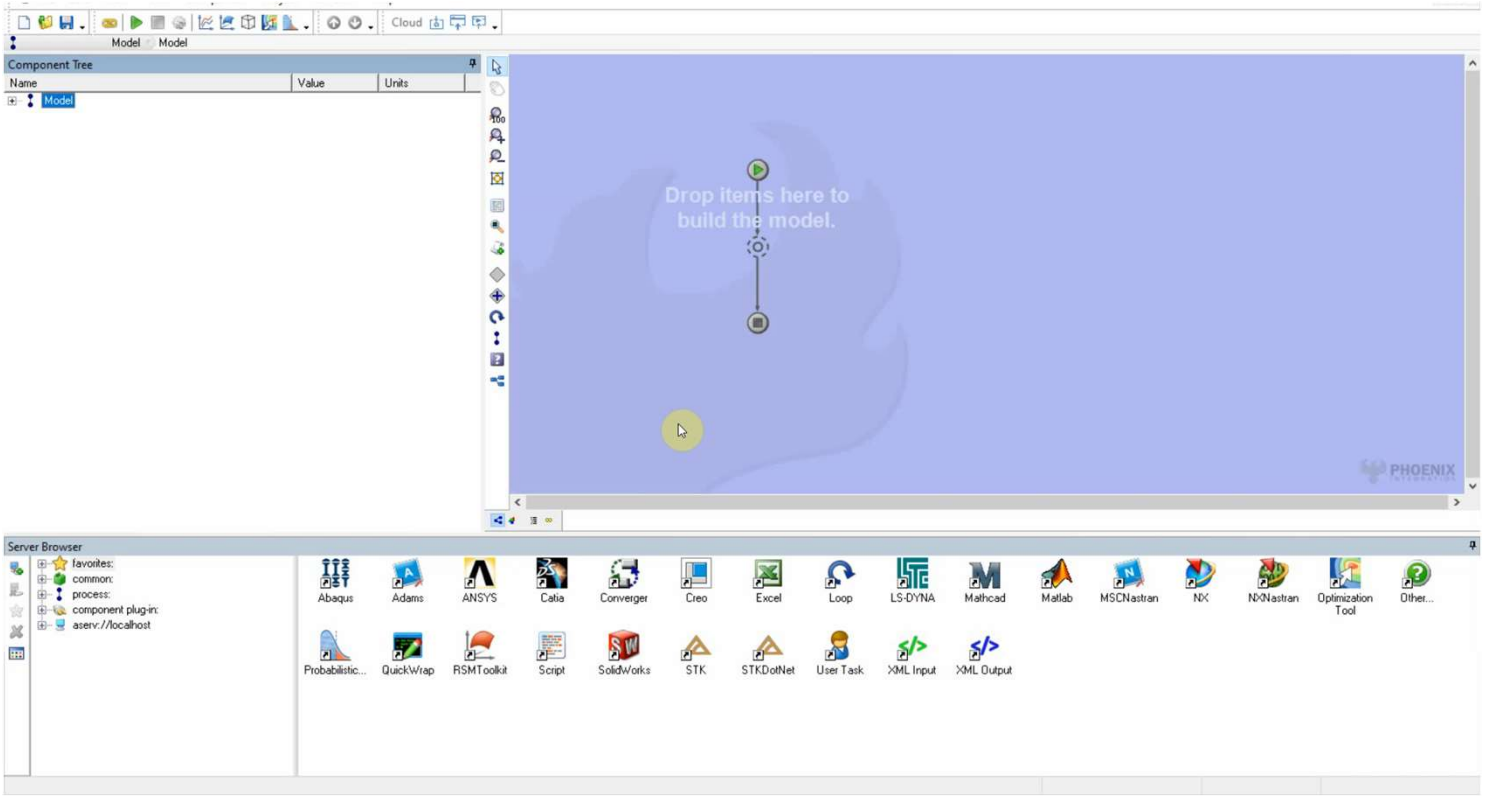
Demo: Automating Excel



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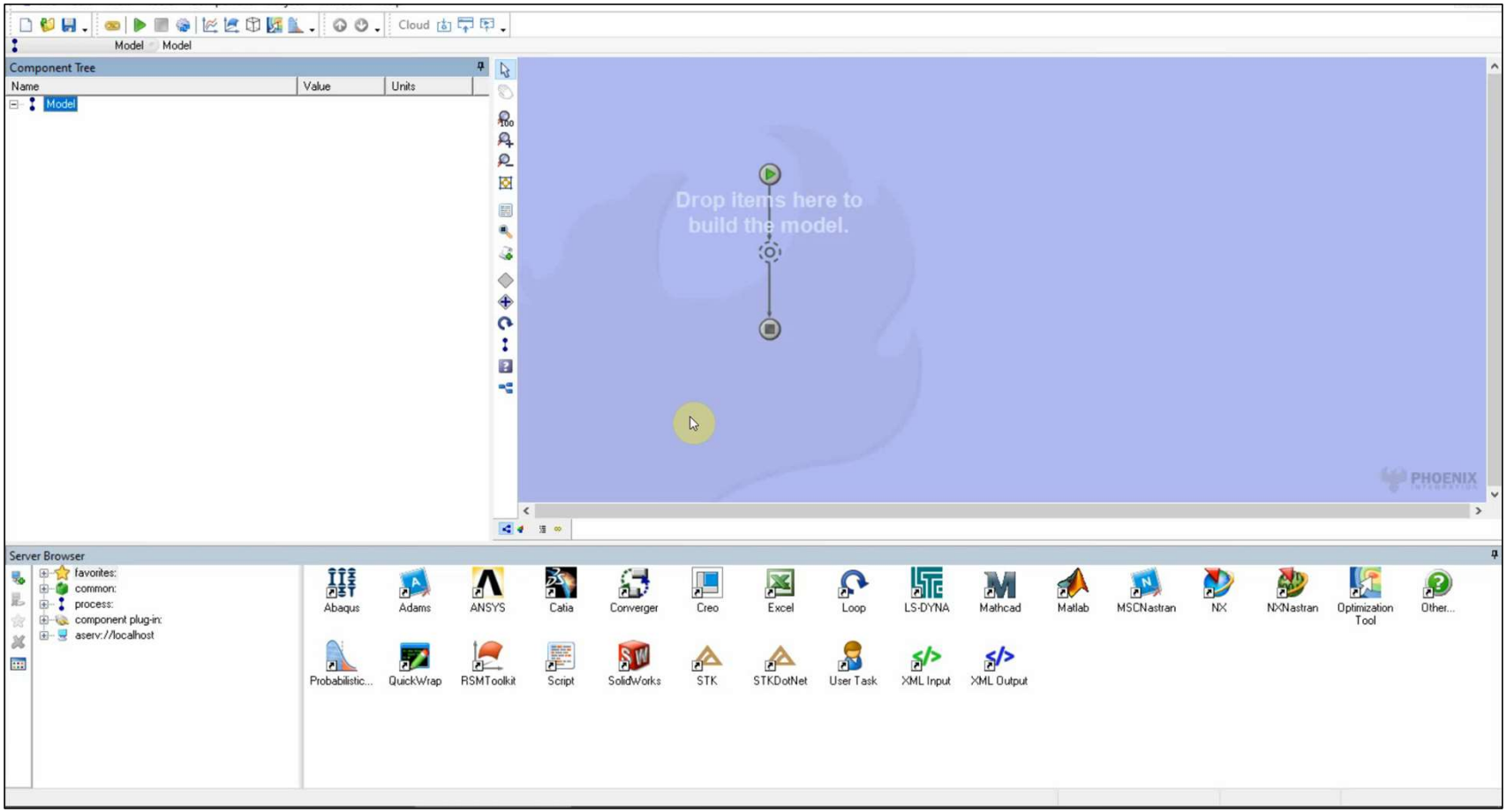
Demo: Automating STK



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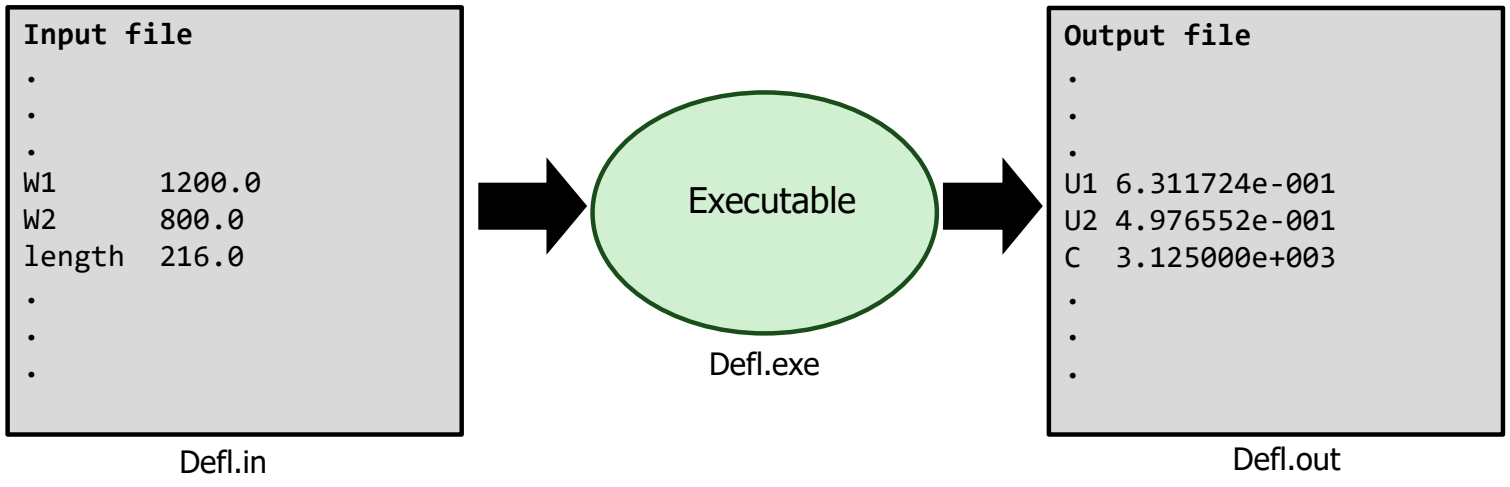
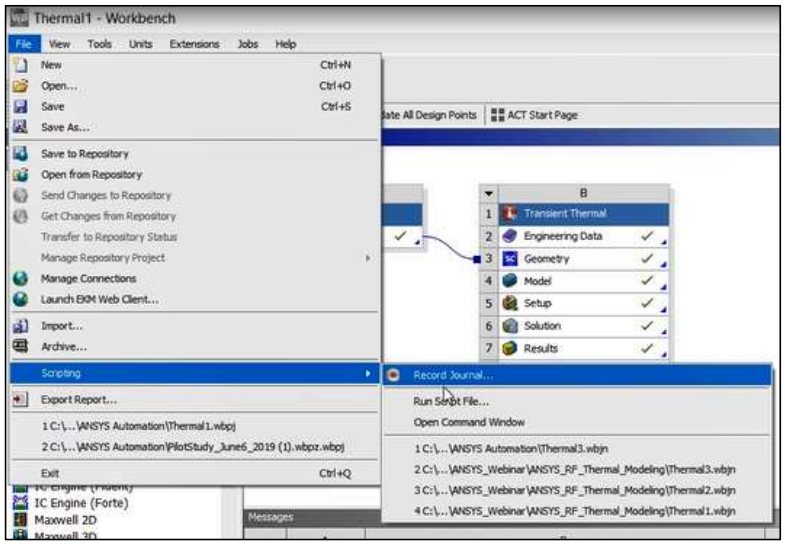
Automating File I/O




```
C:\>"C:\Users\sjohnson\Documents\PHX Trainings\Defl.exe" -i Defl.in -o Defl.out
```

Automating ANSYS (File I/O)

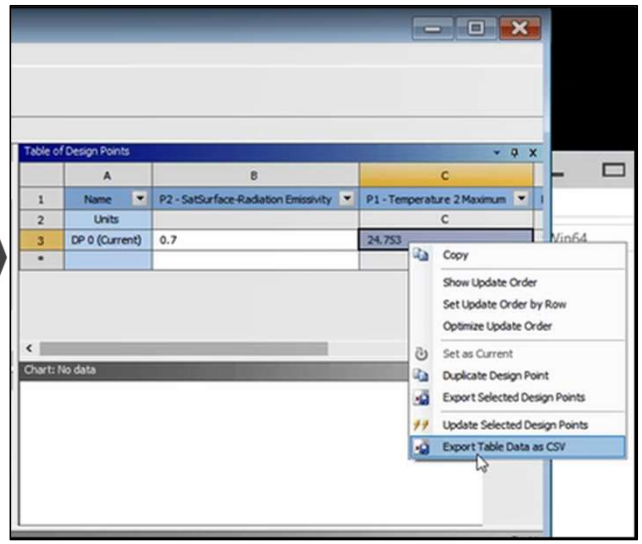
Input File



Executable

ANSYS Workbench

Output File




```
C:\>"C:\Program Files\ANSYS Inc\v193\Framework\bin\Win64\runwb2" -F Thermal1.wbpj -B -R Thermal3.wbjn
```

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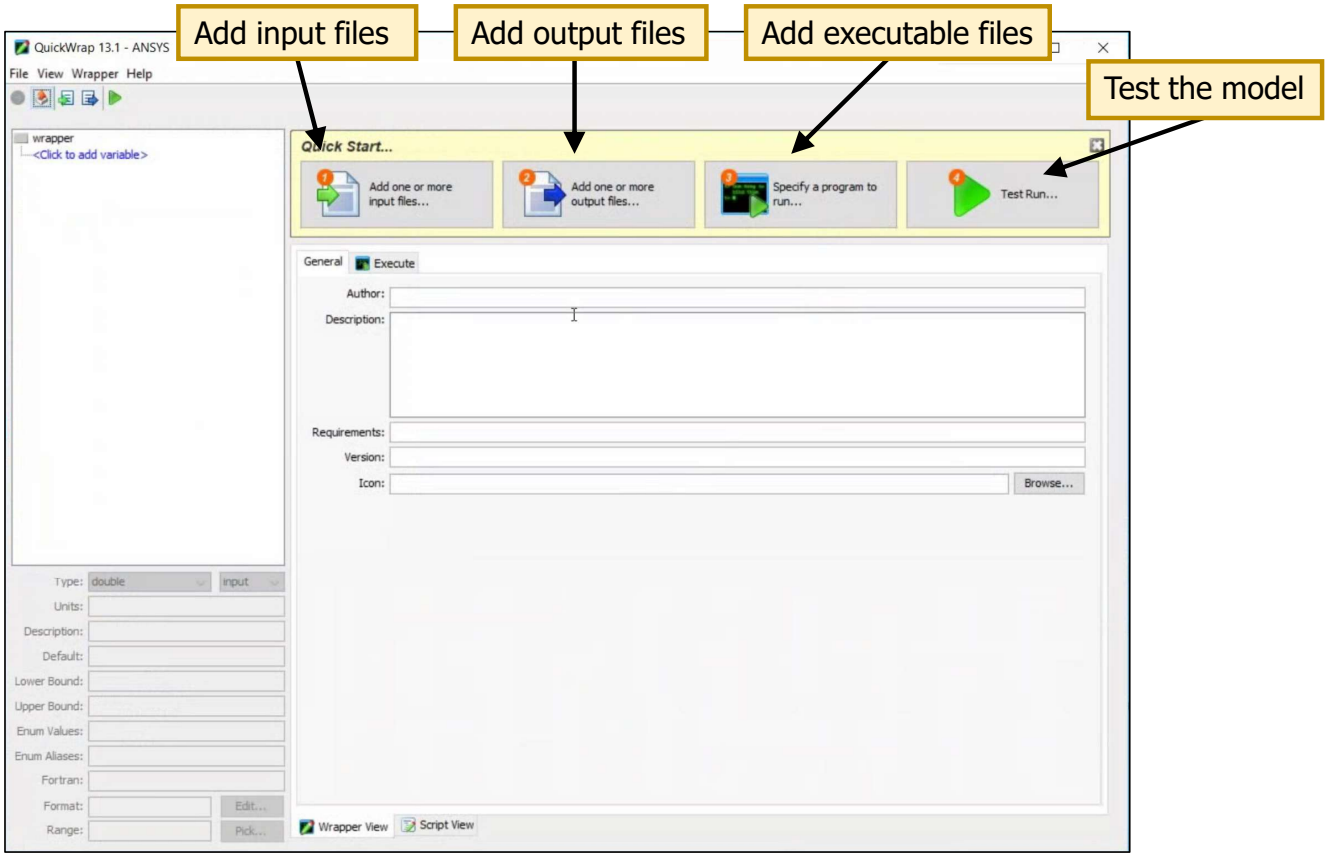
Automating ANSYS



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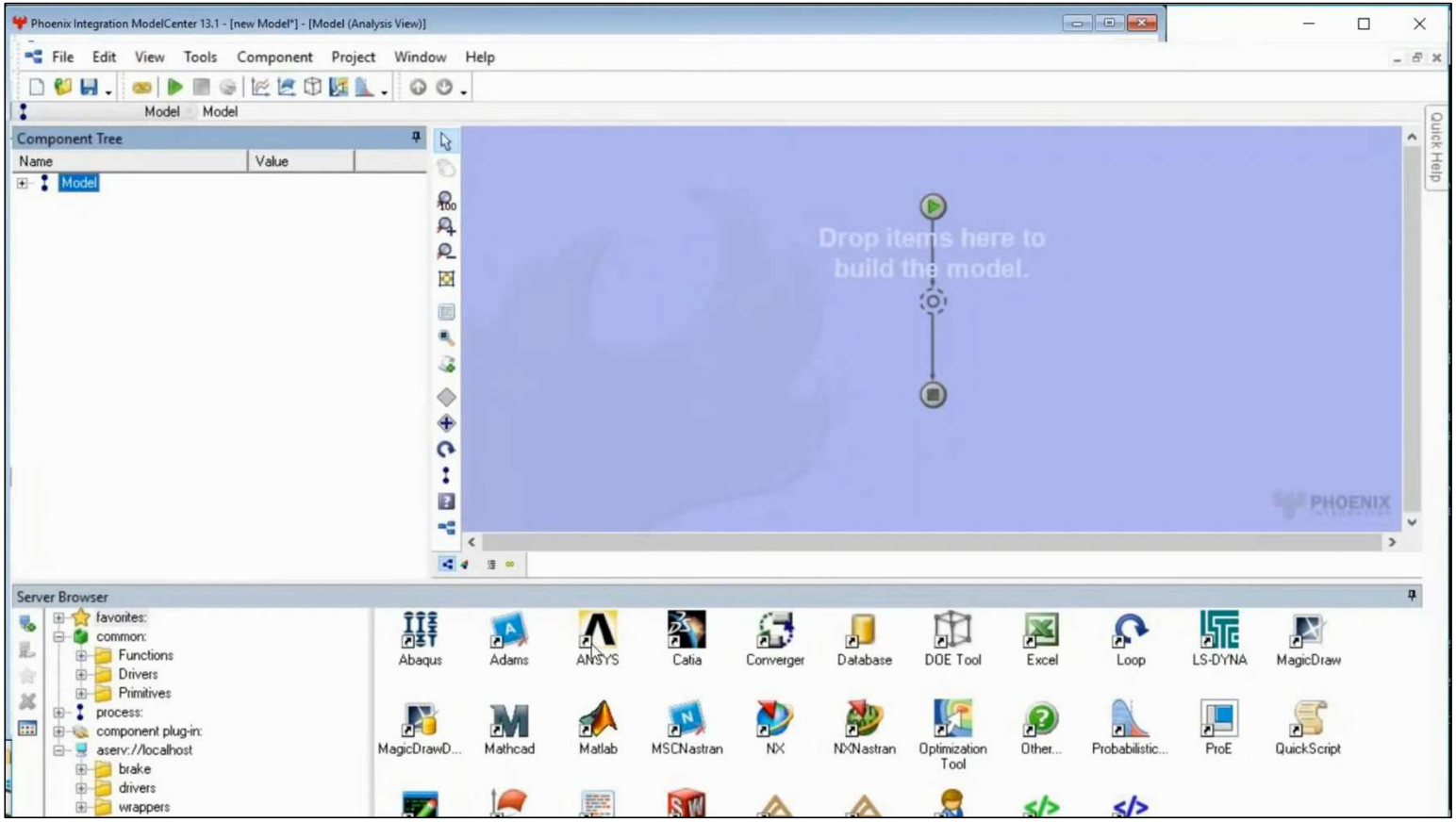
Demo: Automating ANSYS



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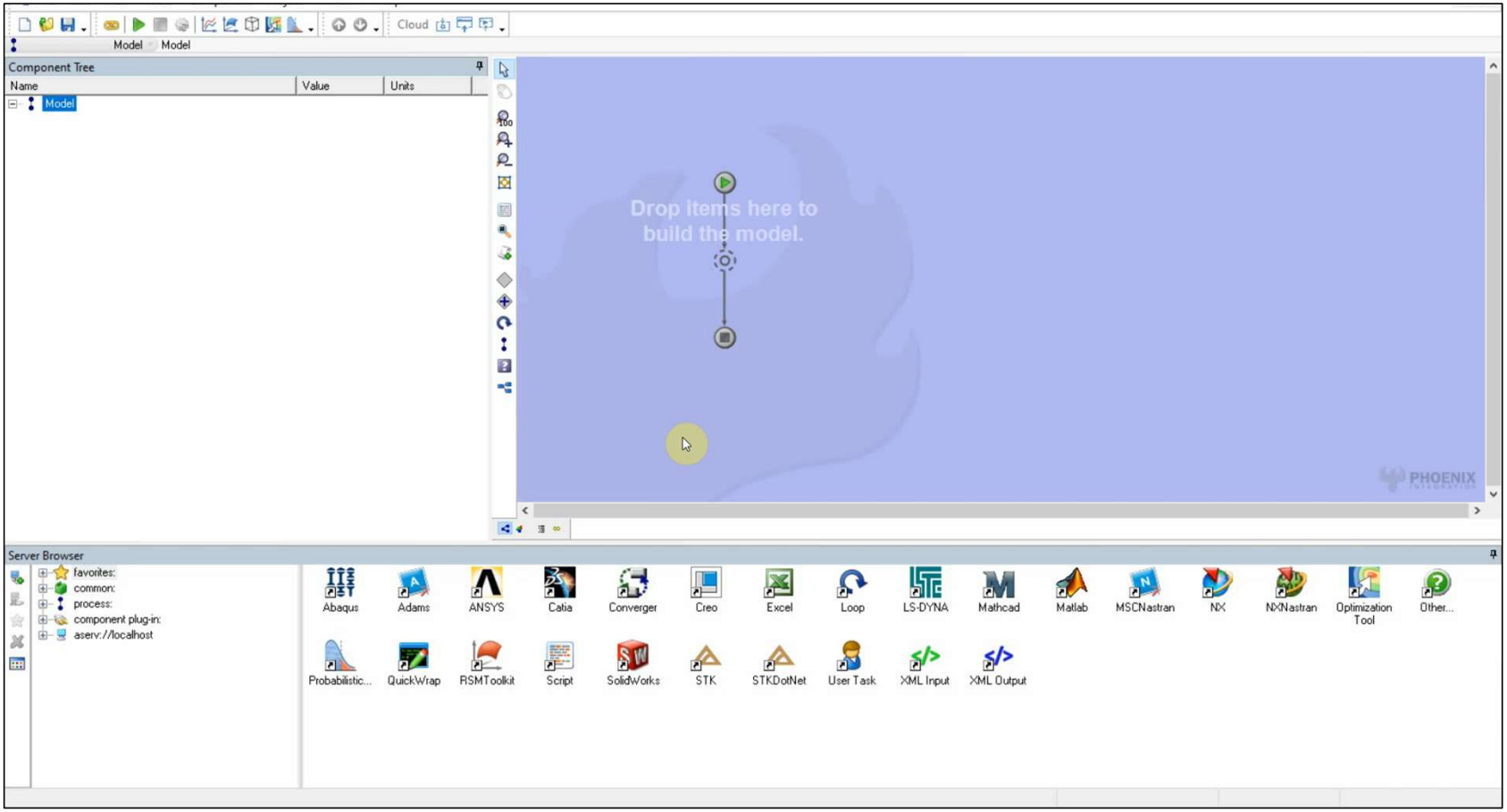
Demo: Automating Scripts



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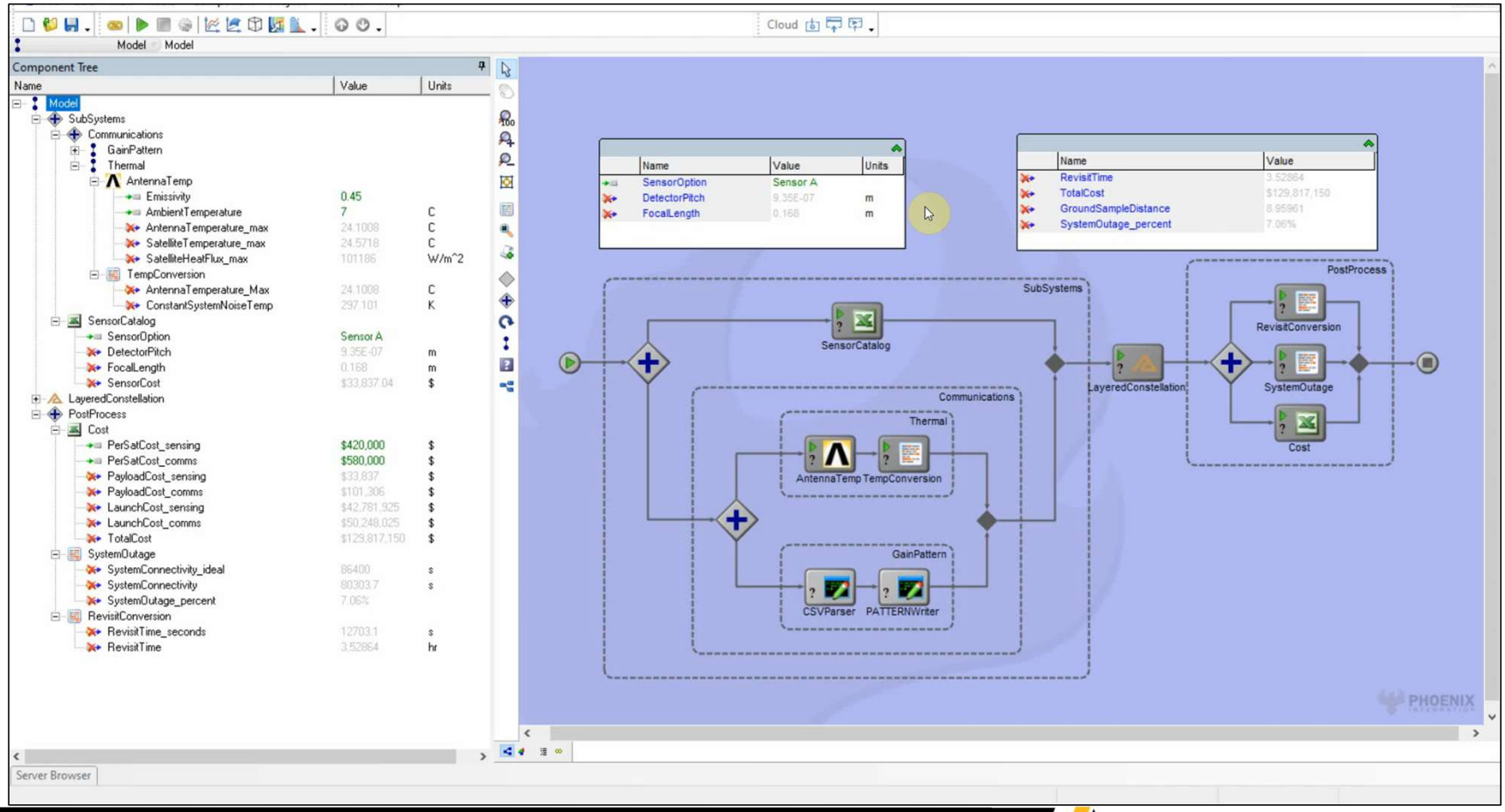
Demo: Executing the Wildfire Workflow



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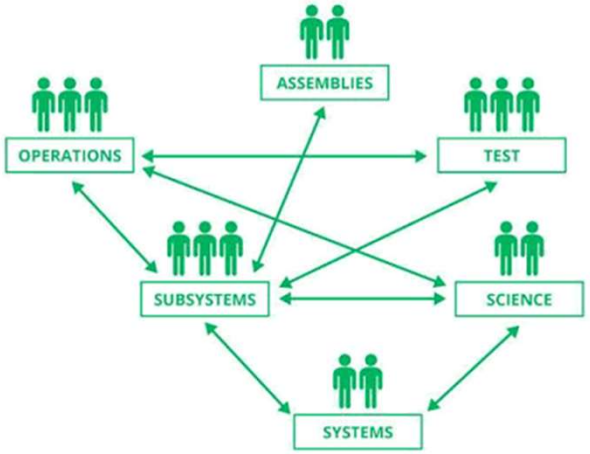
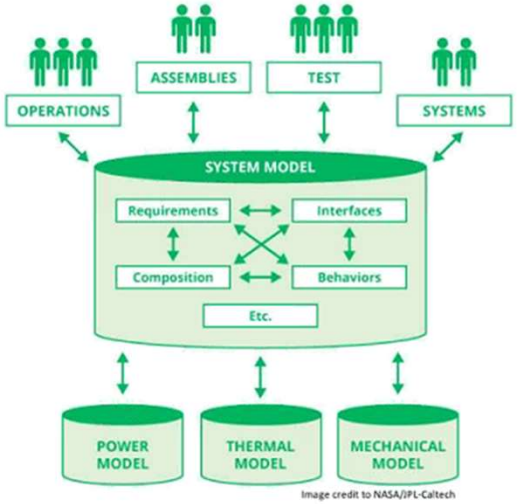
Connect ModelCenter workflow to Cameo SysML model

Ansys

MBSE in a Nutshell



Traditional Systems Engineering



Model Based Systems Engineering

Massachusetts Institute of Technology

http://sysengonline.mit.edu/

- ModelCenter Integrate
  - **Automate**
  - **Integrate**
  - To Create a Workflow
- ModelCenter Explore
  - **Iterate** The Workflow
  - Design Studies
  - Optimizations
  - Risk/Reliability
- ModelCenter MBSE
  - Integrate **Systems Engineering** Models with **Analytical** Models.

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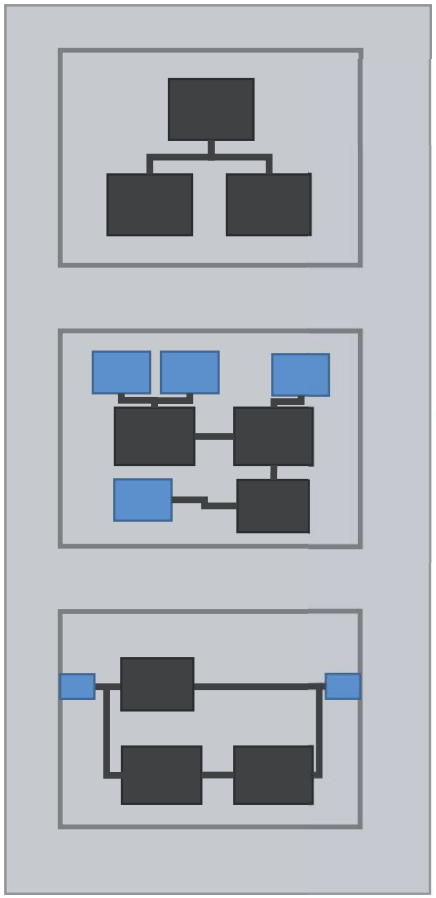
System Model



Descriptive
- Behavior
- Requirements
- Structure

Dynamic, Low to High-Fidelity Models
- Behavior Simulation
- Requirements Verification
- Trade Studies

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Mechanical

Electrical

Simulation

Cost

Manufacturing

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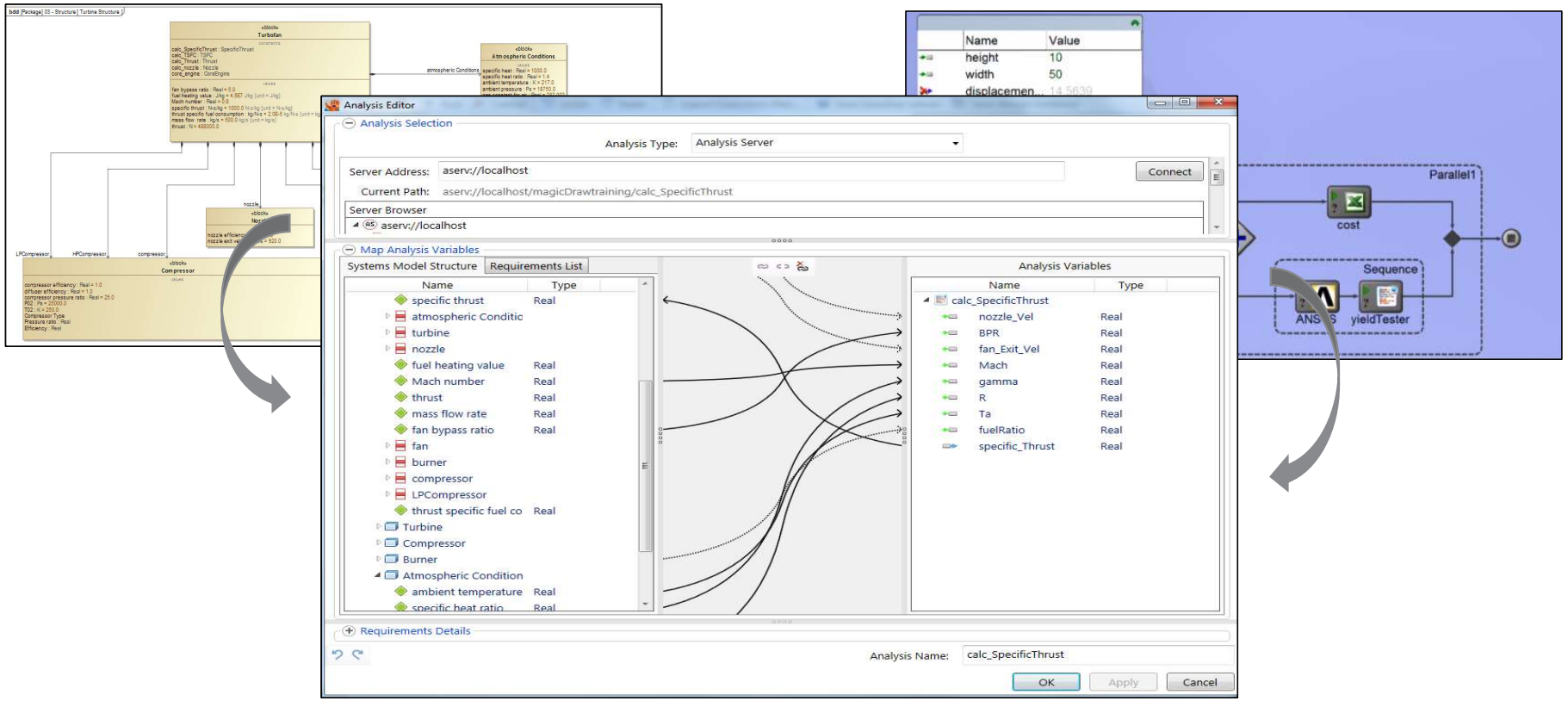

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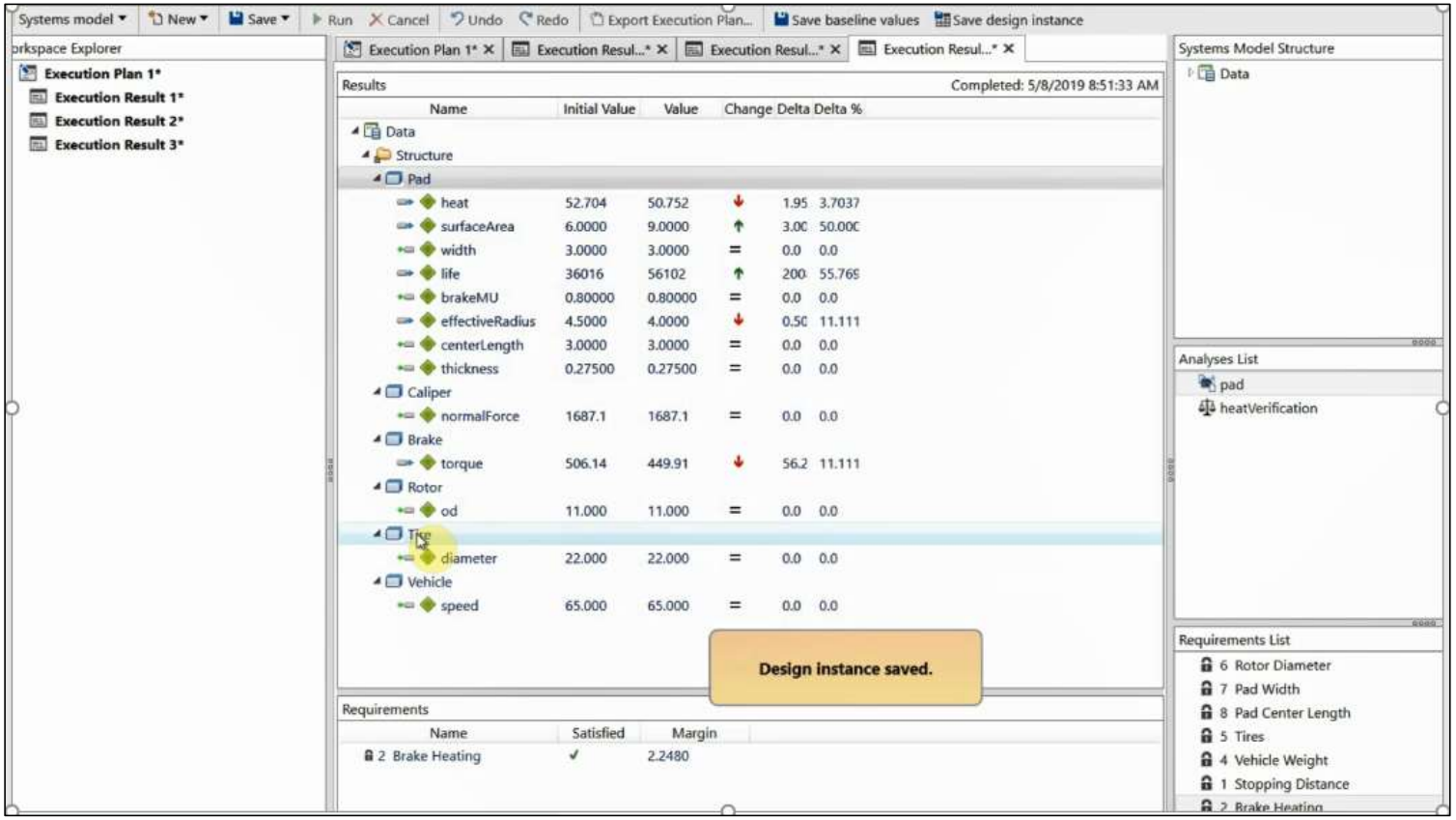
ModelCenter MBSE



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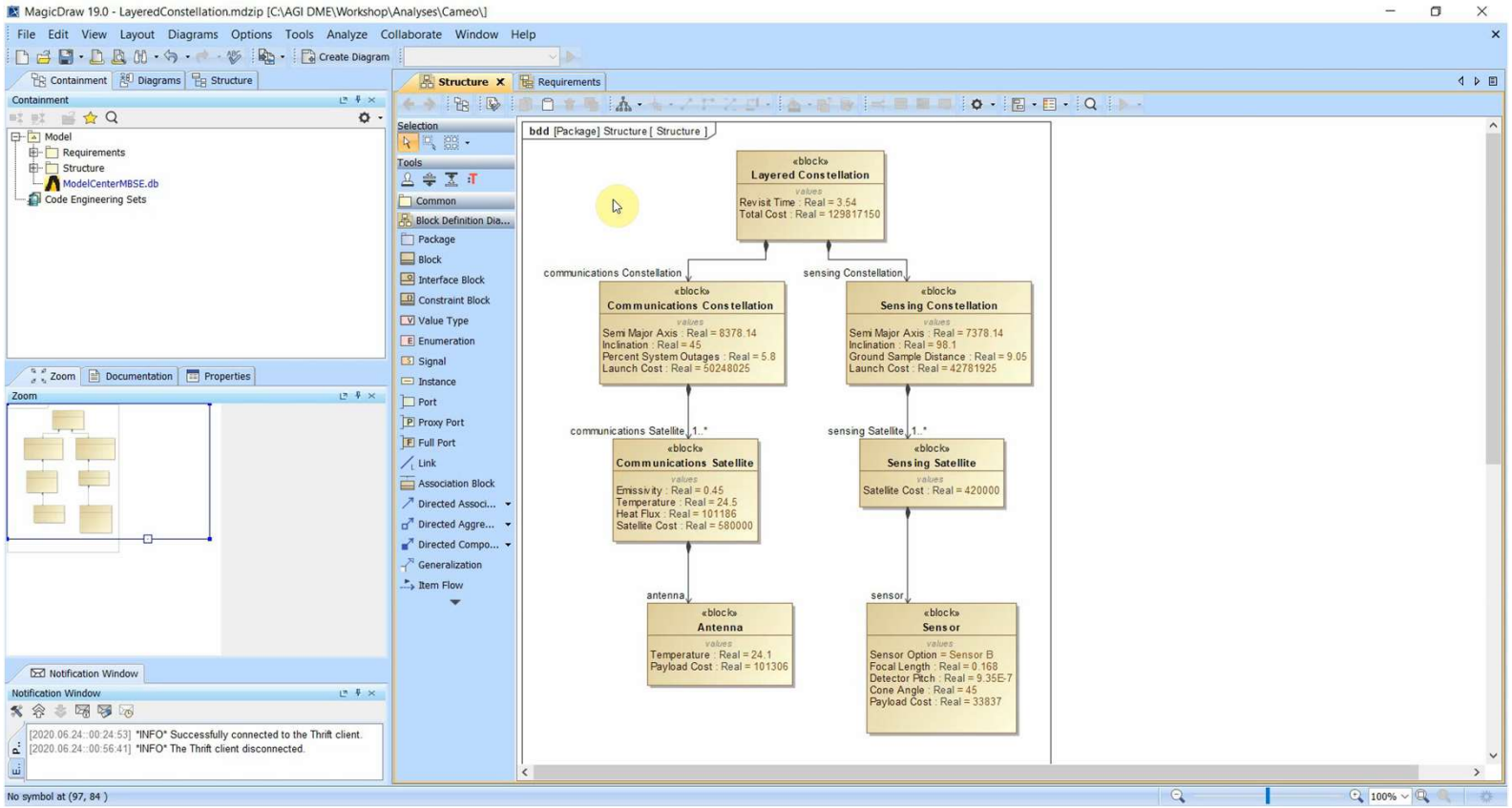
Demo: Integrating SysML with ModelCenter MBSE



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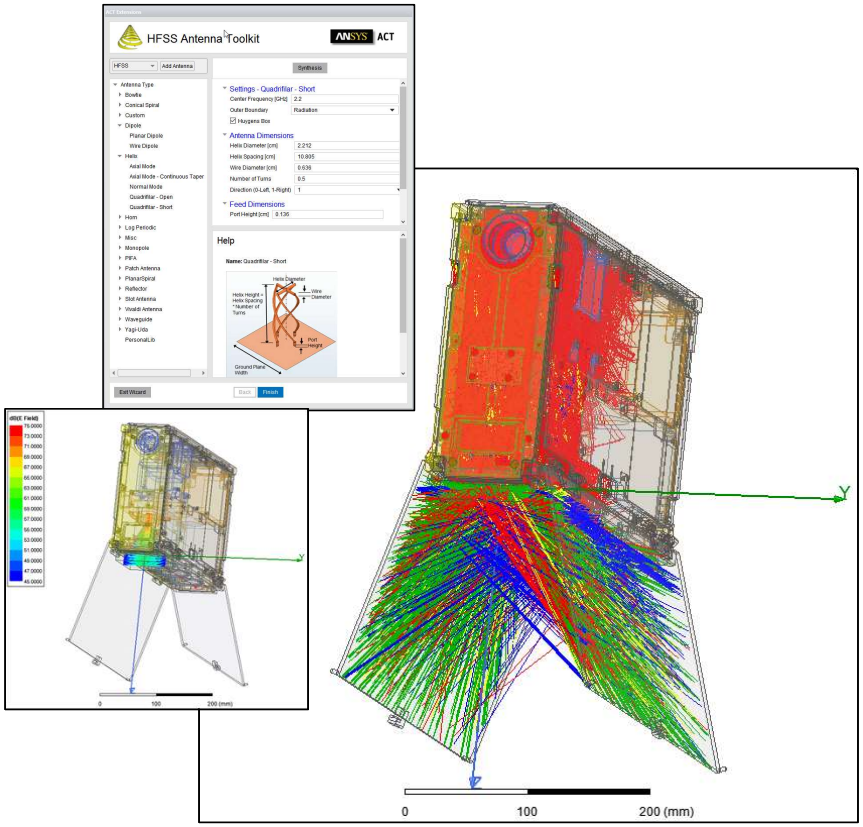
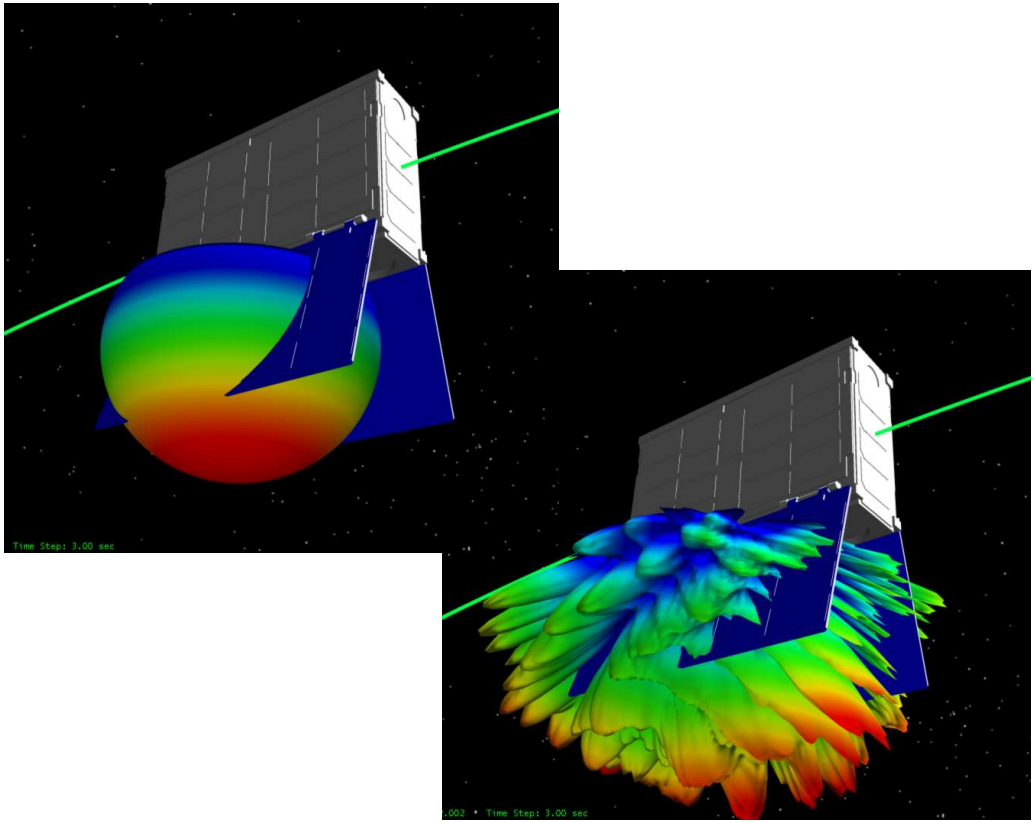
Increase the fidelity of the antenna pattern for STK

Ansys

Installed Performance: Capturing the Cubesat Interaction



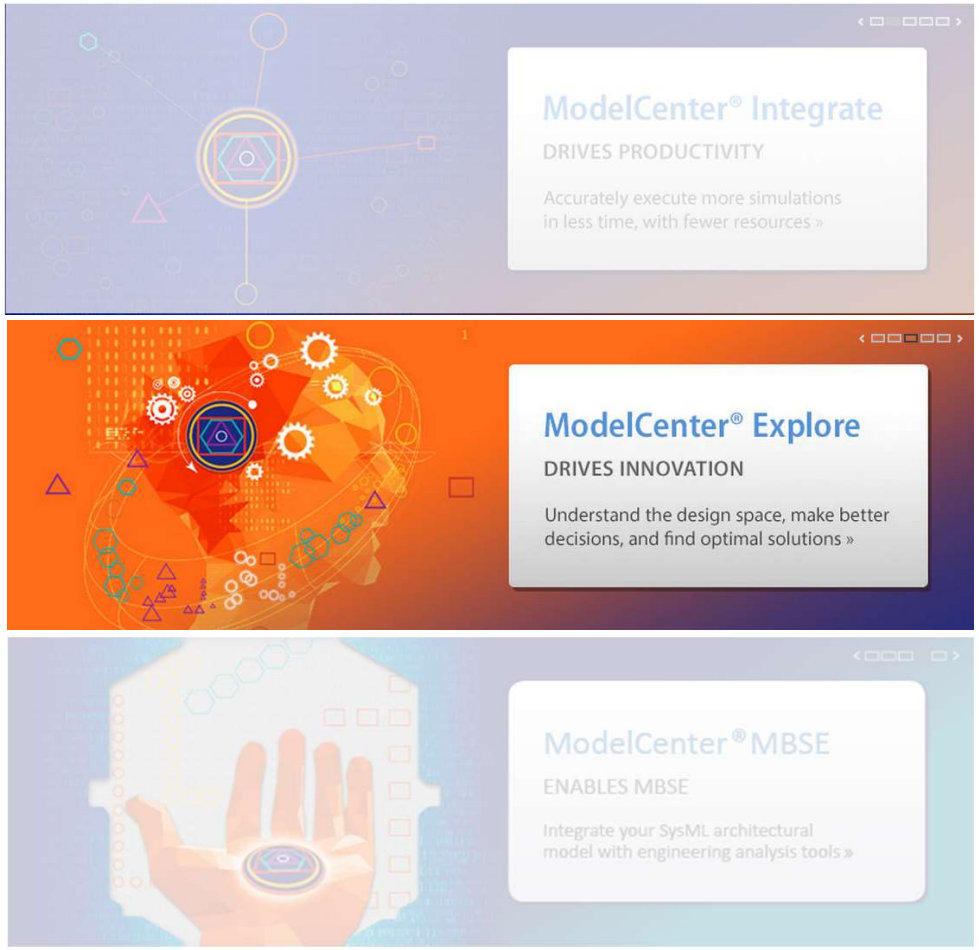


Handle requirements changes in the SysML model

Ansys

Mission Requirements Change

1. The sensing system shall collect imagery with a **ground sample distance** less than **6 meters** in order to detect any wildfire in North America greater than **1 acre**
2. The communications system shall provide link availability with less than **7.5% outage** which corresponds roughly to one orbital period per day
3. Overall system **revisit time** shall be less than **4 hours** to support an adequate response time
4. **Total cost** shall be less than **$130 million**



- ModelCenter Integrate
  - **Automate**
  - **Integrate**
  - To Create a Workflow

- ModelCenter Explore
  - **Iterate** The Workflow
  - Design Studies
  - Optimizations
  - Risk/Reliability

- ModelCenter MBSE
  - Integrate **Systems Engineering** Models with **Analytical** Models.

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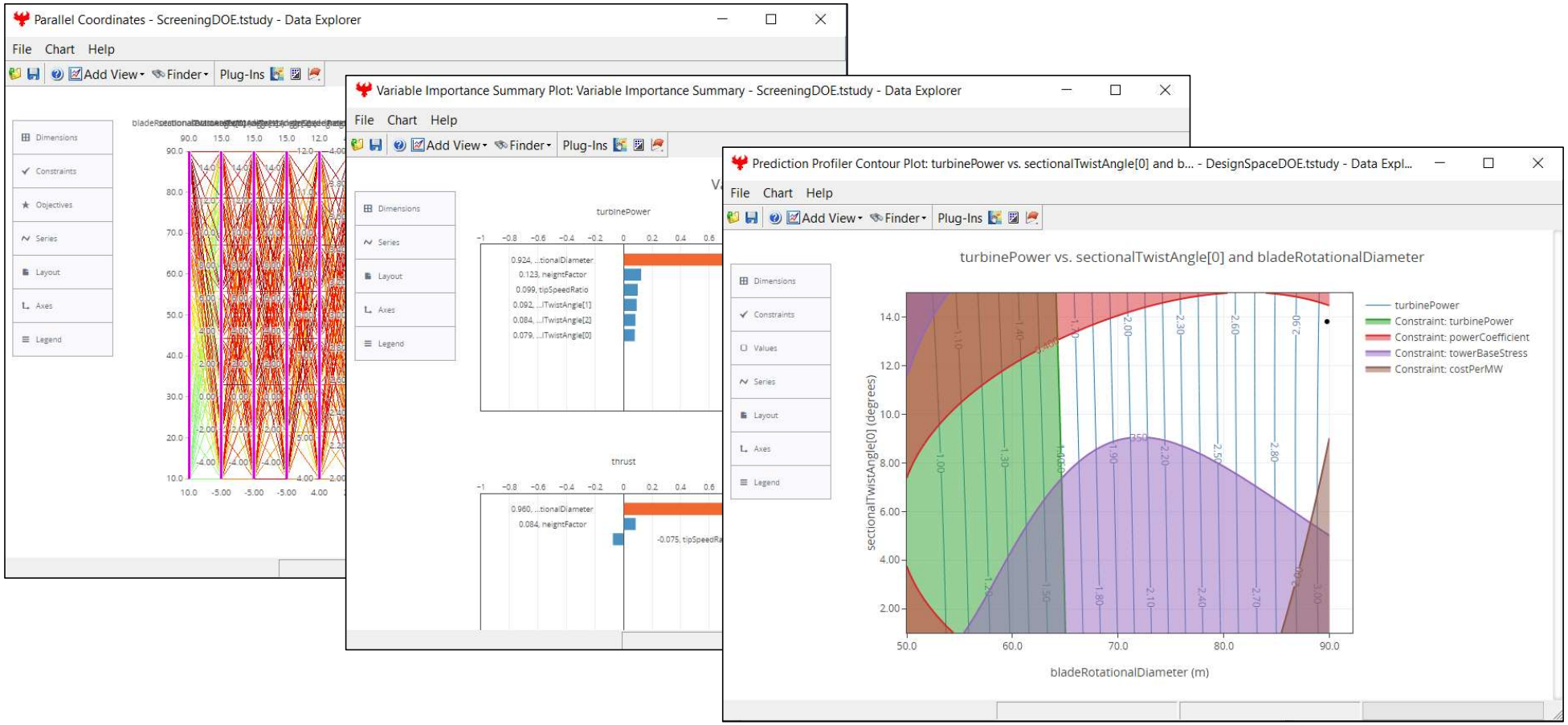
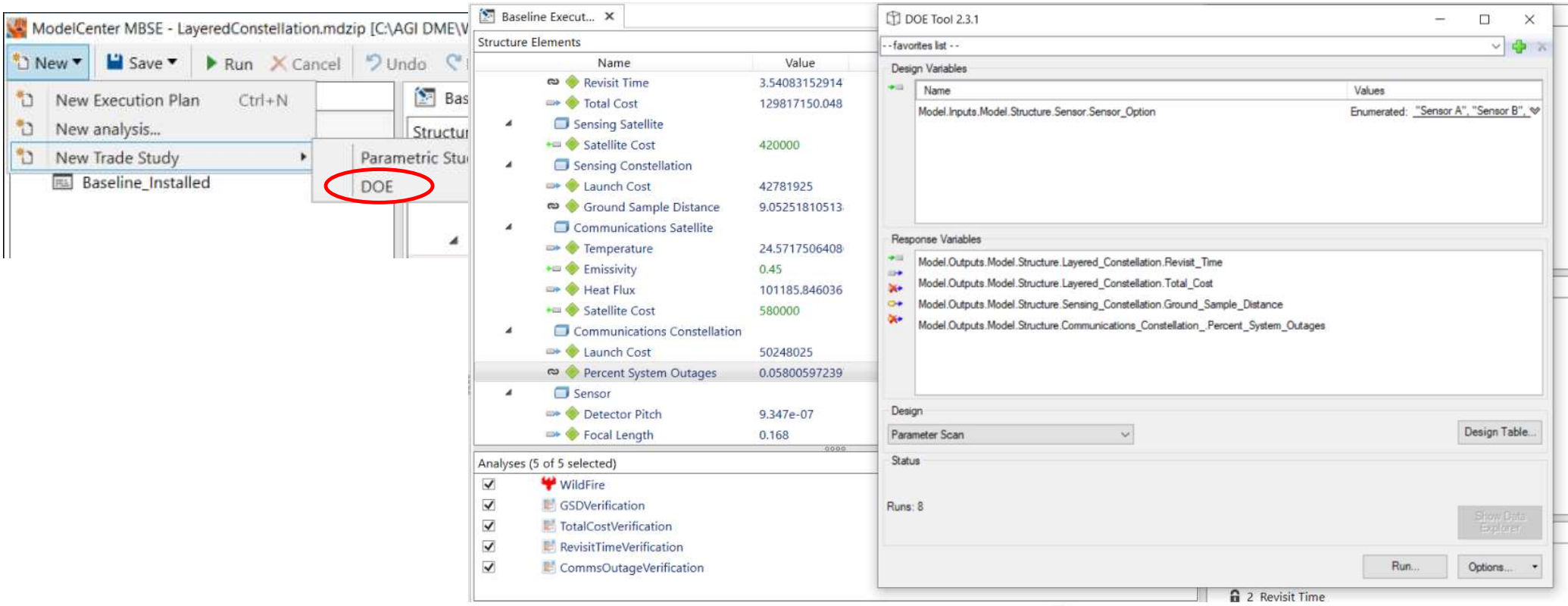
ModelCenter Explore



Design Exploration in ModelCenter MBSE



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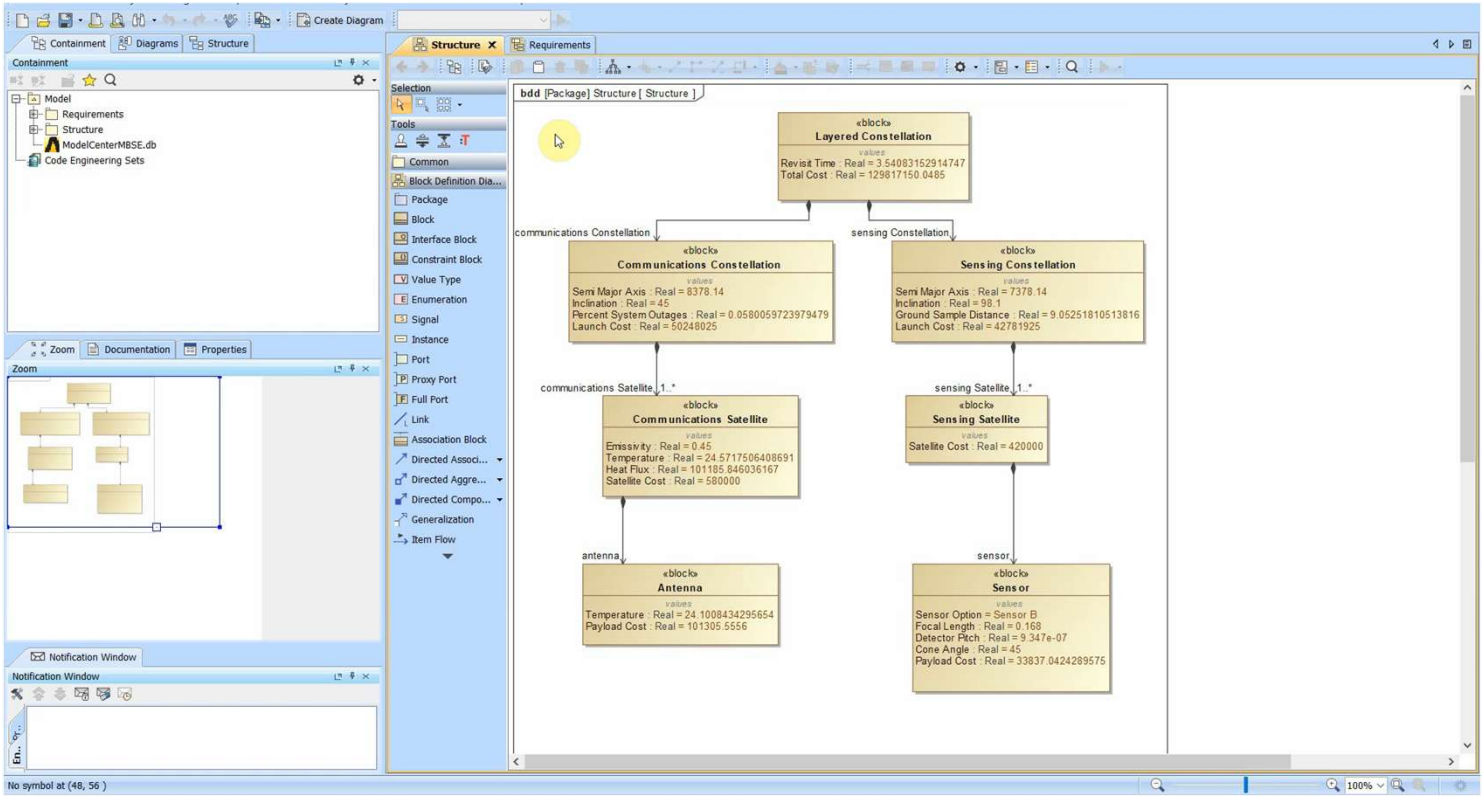
Demo: Handling Requirement Changes



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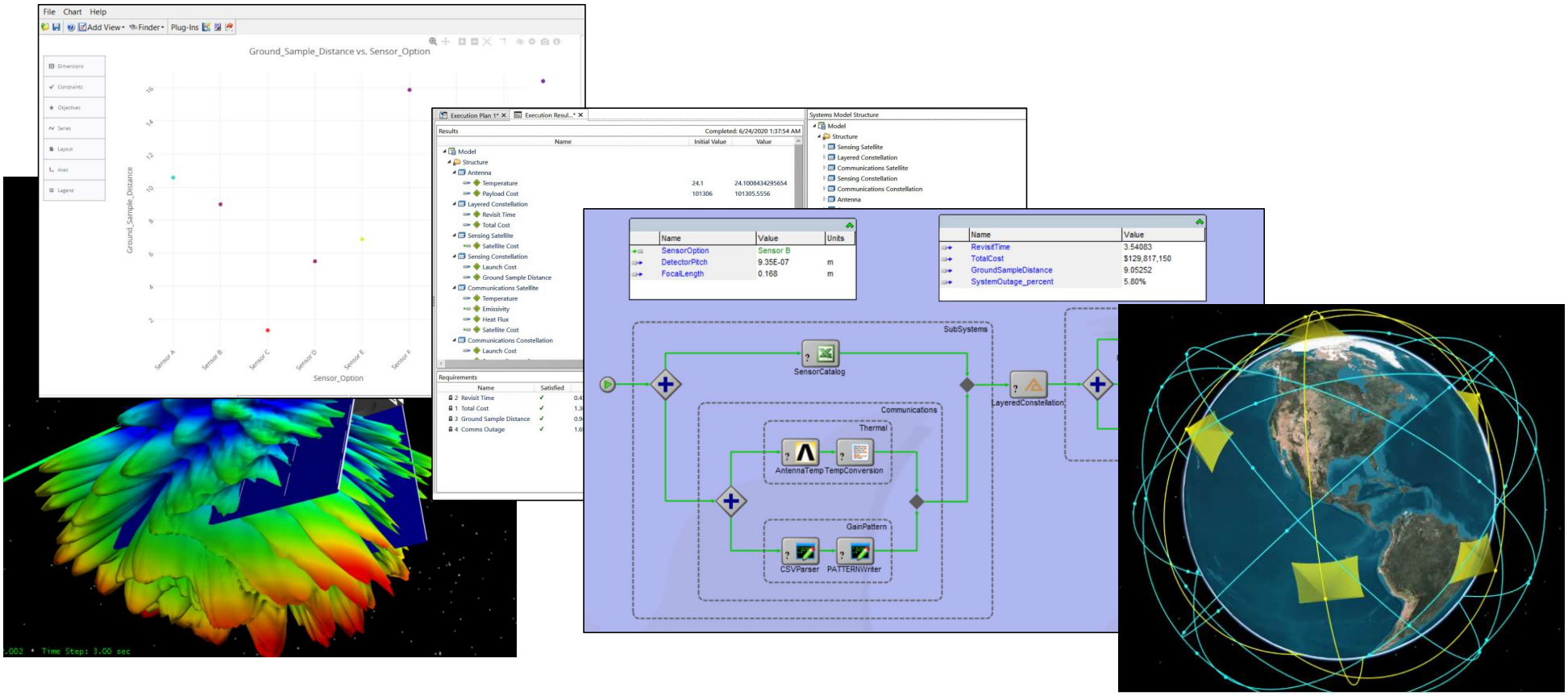
Demo Summary



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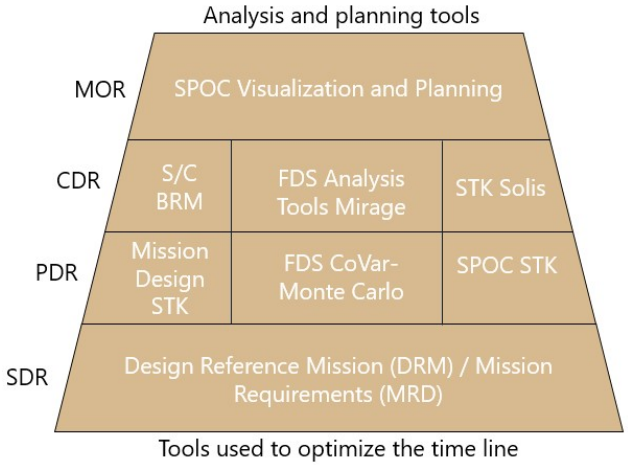
OSIRIS-Rex

https://www.agi.com/blog/2020/10/tagging-asteroid-bennu

Digital Mission Engineering Case Study



https://ntrs.nasa.gov/citations/20150002855

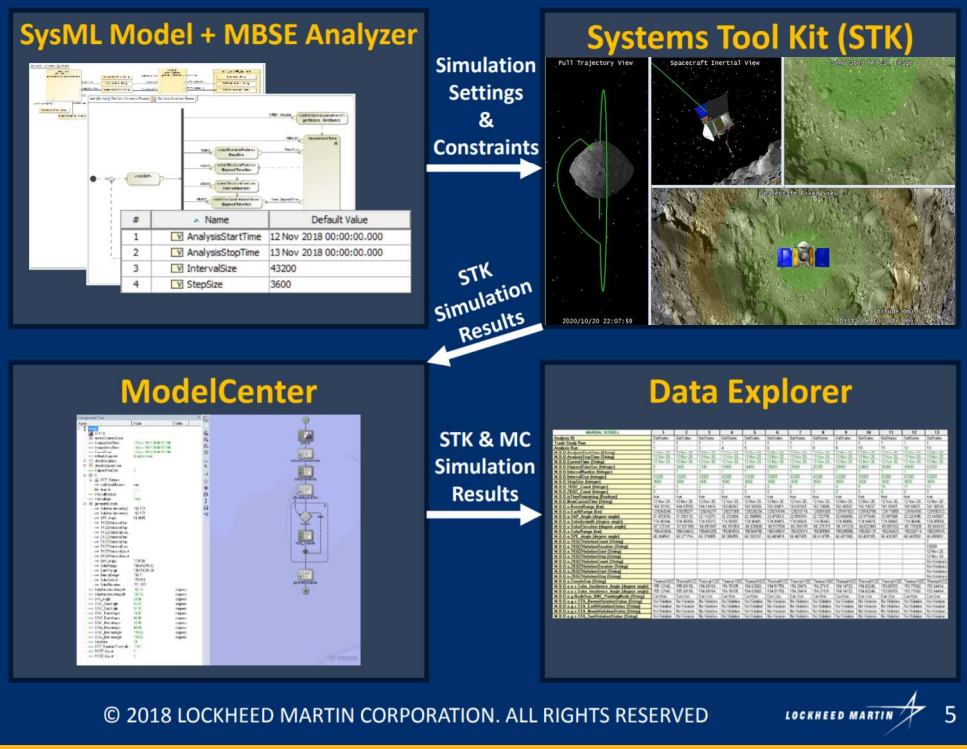
Rick Ambrose • 2nd
Executive Vice President of Lockheed Martin Space | LinkedIn Top Voice in Tech...
1d • Edited •

The OSIRIS-REx spacecraft had a successful rendezvous with the asteroid Bennu! The spacecraft's robotic arm briefly touched the asteroid, deployed nitrogen to collect a pristine sample, and successfully backed away from the asteroid. In the coming weeks, we'll learn whether or not the attempted sample collection was a success, but this was certainly a significant milestone to reach – especially at 207 million miles away from Earth. Congratulations to the team! #ToBennuAndBack

Overview
Challenges
Objectives
Approach
Modeling
Simulating
Results
Reflections
Future Work

https://www.phoenix-int.com/integrated-model-based-systems-engineering-mbse-applied-simulation-osiris-rex-mission-lockheed-martin-space/

APPROACH



Ansys technology was an essential part of the Design Reference Mission, through PDR, CDR and for Operations. True Digital Mission Engineering from concept through operations.

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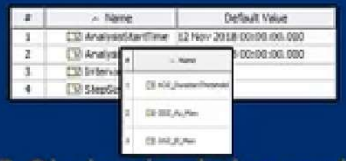
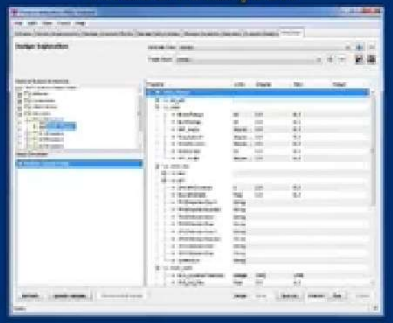
SIMULATION PROCESS OVERVIEW

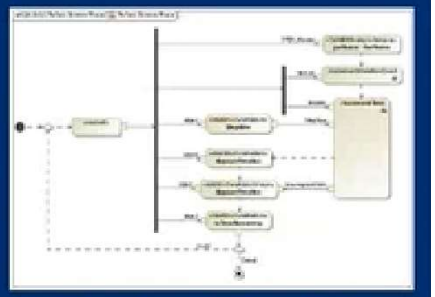
1. Enter simulation settings and constraints.



2. Initiate simulation from MBSE Analyzer.

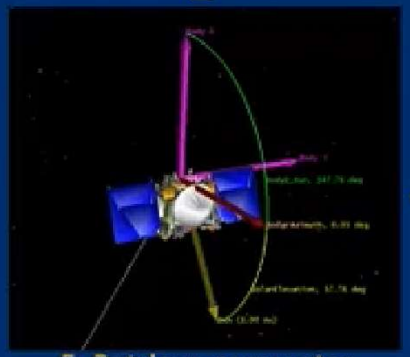


3. Step through the mission simulation.

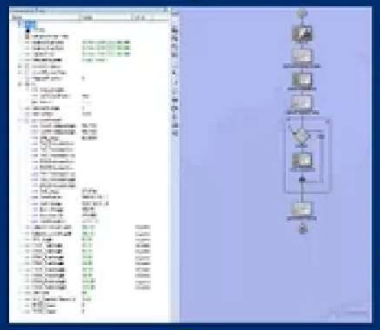


4. Point to external analysis tools.

5. Retrieve parameter values from STK.



6. Evaluate STK parameters; return results to MBSE Analyzer.



7. Display simulation results for each time step.

LOCKHEED MARTIN

Integrated Model Framework Example

Descriptive to Analytical and Back

NORTHROP GRUMMAN

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